POULTRY
Science and Practice

FIFTH EDITION

POULTRY

Science and Practice

By

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Preface

POULTRY SCIENCE IS ONE of the newest agricultural sciences, although poultry keeping has been practiced for centuries in most countries of the world.

Within the last thirty years poultry has changed largely from a backyard enterprise to large-scale specialized production. Chance, luck, art, and skill in production have been replaced by the application of biological science. Economics is also playing an important part in the modern poultry industry.

A great mass of poultry information has been published in recent years. As may be expected in any new science, some of it is based on sound experimental data, some is conflicting, and some is purely hypothetical.

The purpose of this book is to give, what appears to be at the present time, the practical factual information on poultry production and marketing. It includes breeding, incubation, rearing, housing, feeding, disease, marketing, and the economics of poultry production and marketing. Books have been written on each of the subjects covered. In this book an attempt has been made to summarize and provide samples of current information that will be useful for college students beginning the study of poultry science and for people in other fields who need a general knowledge of the poultry industry.

References, mostly typical samples of recent publications, have been listed at the end of each chapter. No attempt has been made to provide a complete bibliography on any subject covered. The references listed generally cite others where additional information may be found. The Appendix also contains suggestions for obtaining additional information on poultry subjects.

The authors greatly appreciate the help and constructive criticisms given by their associates in the preparation of the textbook. We especially wish to thank Dr. H. V. Biellier for suggestions on Chapter 3, Anatomy and Physiology; Dr. R. George Jaap and Dr. A. B. Stephenson for Chapter 4, Breeding; Dr. J. E. Savage and Dr. E. C. Naber for Chapter 8, Feeding; Dr. Glyde Marsh for Chapter 9, Diseases; Dr. Owen Cotterill and Dr. Paul Clayton for Chapter 10, Marketing Eggs; Dr. George Mountney for Chapter 11, Marketing Poultry; and Dr. Paul Clayton and Prof. Q. B. Kinder for Chapter 12, Economics of Poultry Production and Marketing.

The authors greatly appreciate the courtesies extended by various organizations and individuals in permitting the use of illustrations and tables. Credit has been given in all such cases.

A. R. WINTER
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Contents

POULTRY

Science and Practice

Chapter 1

The Poultry Industry

Introduction

Definition of poultry. The term "poultry" is used to designate those species of birds which render man an economic service and reproduce freely under his care. It includes chickens, turkeys, ducks, geese, swans, guineas, pigeons, peafowl, pheasants, and ostriches, and refers to them whether alive or dressed.

Relation of poultry to other animals. There are about 600,000 species of animals in the world, including 10,000 species of birds. They are classified according to structure.

The most highly developed animals (Fig. 1–1) are mammals, which include man and farm animals, and aves or birds. Mammals are distinguished by the presence of hair and mammary glands. Birds are distinguished by the covering of feathers.

Poultry science. Poultry science is the study of principles and practices involved in the production and marketing of poultry and poultry products. It includes breeding, incubation, brooding, housing, feeding, disease, marketing, and poultry-farm management.

The study of the great numbers of birds not classed as poultry is *ornithology*. The science of all animal life is *zoology*.

Importance of the Poultry Industry

Source of farm income. Probably more persons are directly interested in poultry production than in any other single agricultural enterprise. More than 60 per cent of all farms in the United States reported poultry in 1958. These figures do not include the many backyard chickens kept as pets or for the family supply of eggs. Poultry ranked fourth in gross income among agricultural commodities in the United States in 1959 (Fig. 1–2).

Source of food supply. Poultry eggs and meat are used chiefly as human food.

Eggs have more nutritional value than any other food (Table 1–1). They are a good source of proteins, minerals, and vitamins. Eggs are palatable, easily digested, and can be used in a great variety of appetizing ways (Fig. 1–3). They serve as binders and leavening agents in baking and furnish "richness" in icings, sauces, candies, custards, ice cream, etc. The estimated annual per capita consumption of eggs in the United States in 1958 was 348.

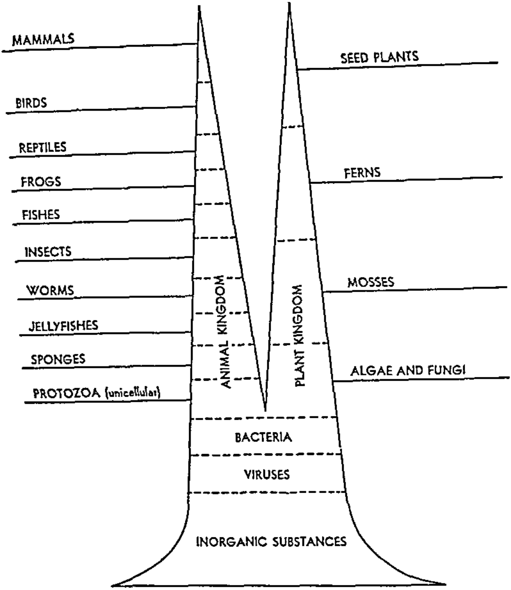


Fig. 1–1. A diagram illustrating the probable relationships of living things.

Poultry meat is supplied chiefly by chickens, turkeys, ducks, geese, and guinea fowls. The percentage of edible meat obtained from poultry on the ready-to-cook basis, is higher than that obtained from other meats (Table 1–2). Poultry meat is probably the most palatable of all meats and is easily digested. It is served in a variety of ways such as fried, roasted, or stewed, and in combination with other foods as in salads, sandwiches, sauces, soups, etc. (Fig. 1–3). The annual per capita consumption of poultry meat in the United States in 1958 was about 34 pounds.

Industrial uses. *Fertile eggs* are used in the preparation of vaccines (Fig. 1–4).

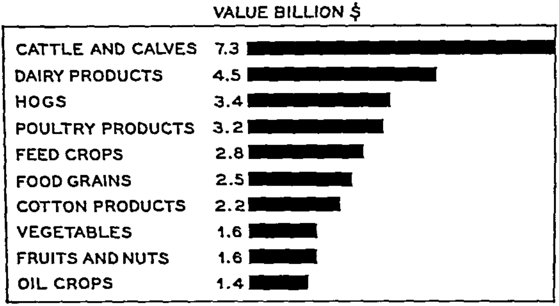


Fig. 1–2. The gross value of leading agricultural products produced in 1957. (U. S. D. A. Agr. *Statistics* 1958)

Table 1–1

COMPOSITION OF EGGS AND MILK (1 LB. AS PURCHASED) [1]

Nutrient	Whole Egg	White	Yolk	Whole Milk
Energy (calories)	655	227	1640	309
Protein (grams)	51.7	49	74	15.9
Fat (grams)	46.5	...	144.8	17.7
Total carbohydrates (grams)	2.8	3.6	3.2	22.2
Calcium (milligrams)	218	27	667	536
Phosphorus (milligrams)	848	77	2660	422
Iron (milligrams)	10.9	0.9	32.7	0.3
Vitamin A (International units)	4590	...	14590	720
Thiamine (milligrams)	.39	..	1.24	.16
Riboflavin (milligrams)	1.17	1.17	1.58	.78
Niacin (milligrams)	0.3	0.5	Trace	.5
Ascorbic acid (milligrams)		...	0	6.0
Refuse (per cent)	11.0	...	0	0

[1] U. S. Dept. of Agr. Agr. Hndbk. No. 8.

Inedible eggs are used in the preparation of animal foods and fertilizers.

Egg whites are used in the manufacture of pharmaceuticals, paints, varnishes, adhesives, and printer's ink. They are also used in photography, bookbinding, wine clarification, tanning leather, and in textile dyeing.

Egg yolks are used in the manufacture of soap, paints, and shampoos. They are also used in finishing leather and in bookbinding.

Eggshells are used in mineral mixtures and for fertilizer.

Feathers are used in the making of millinery goods, pillows, cushions, mattresses, dusters, insulation material, animal feed, and fertilizer.

Endocrine glands are used in the preparation of biological products.

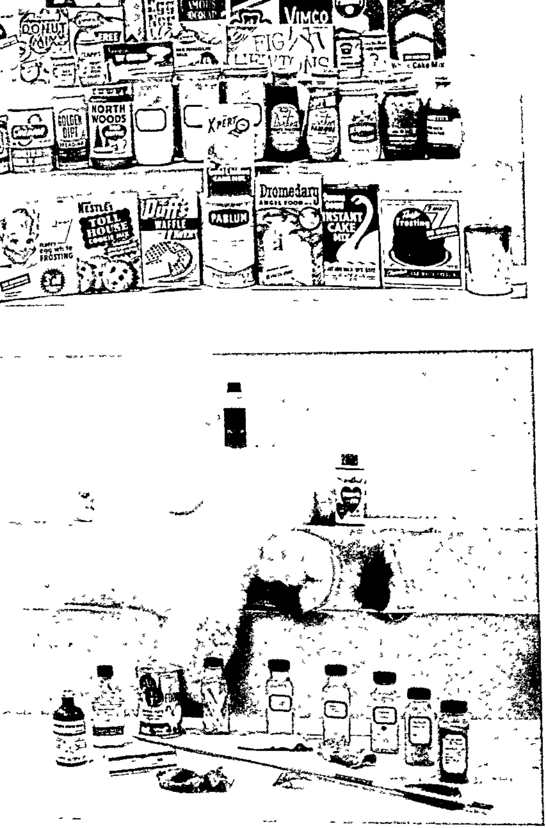


Fig. 1-3. Some uses of poultry products. Top—Products containing eggs. Bottom—Inedible poultry by-products

COURTESY ELI LILLY AND CO.

Fig. 1–4. Eggs being used for the production of vaccine.

Use in research work. Chickens are being used extensively in biological research work because they are cheap and readily available, reproduce freely, have a sensitive metabolism, and are good laboratory animals (Fig. 1–5). Many of the findings made with chickens in the interest of pure science may be applied in a practical way for improving poultry production.

Table 1–2

COMPARATIVE EDIBLE MATERIAL AND COST OF ANIMAL PRODUCTS FROM DIFFERENT SPECIES OF ANIMALS[2]

Kind of Product	Ave. Live Weight	Dressing Loss	Cooked Edible Portion of Carcass	1958 Prices: Retail Price per Lb.	1958 Prices: Cooked Edible Portion per Lb.
		Per Cent	*Per Cent*		
Beef	950 lb.	40	40	0.69	$1.73
Pork	220	31	32	0.68	1.93
Lamb	85	51	48	0.71	1.48
Broilers	3.4	25	50	0.40	.80
Turkeys	20.4	23	59	.49	.83
Eggs 8 per lb.	1.0	0	89	.48 to .64	.54 to .72

[2] J. I. Taggart, Hatchmaster Incubator Co., Cleveland, O.

Table 1–3

WORLD DISTRIBUTION OF PEOPLE (1956) AND CHICKENS AND EGGS (1957)

	Population(1) (Thousands)	Chickens(2) (Thousands)	Per Person	Eggs(2) (Millions)	Per Person
North America					
Canada	16 091	43,270	2 7	5416	337
United States	168,174	390,137	2 3	65099	387
Mexico	30,538	74,000	2 4	2700	89
Cuba	5 829				
Dominican Republic	2 608				
Panama	934				
Europe					
Austria	6 983	9,068	1 2	1048	15
Belgium	8,924	17,000	1.9	2720	305
Denmark	4,466	22,890	5 1	2324	520
Finland	4,291				
France	46,348			7900	170
Germany(West)	70,723	53,867	.76	6250	88
Greece	8,031	14,000	1.7	630	78
Ireland	2,898	12,333	4 2	833	281
Italy	48,279			6200	128
Luxembourg	312				
Netherlands	10,888	24,618	2 2	4747	436
Norway	3,462	3,837	1.1	550	159
Portugal	8 837				
Sweden	7,316	11,600	1.6	1500	205
Switzerland	5,039	6,500	1.3	536	106
United Kingdom	51,430	68,958	1.3	10900	211
Yugoslavia	17,886	22,613	1.2		
Spain	20,200				
Asia					
Lebanon	1,450				
Syria	3,970				
Turkey		22,000		1214	
China	630,465				
Japan	90 000	45,341	.50	7036	78
India	387,350				
Philippine Rep	22,265	57,330	2 5	1200	53
Pakistan	83,603				
South America					
Argentina	19,486			3400	174
Brazil	59,846	160,000	2 6	5616	93
Chile	6 944				
Paraguay	1,601				
Peru	9 651	11,700	1 2	400	41
Uruguay	2 650			340	129
Bolivia	3,235				
Africa					
Egypt	23,410			570	24
French Morocco	9,823				
U. South Africa	13,915			1020	73
Fr. West Africa	18,890				
Oceania					
Australia	9,428			2340	248
New Zealand	2,178				

(1) United Nations Statistical Yearbook 1957
(2) U. S D A Foreign Crops and Markets May 22, 1958.

General farm flocks predominate in this region. There is a surplus of poultry products in most states of the area (Fig. 10–2).

The North Atlantic states produce about 17 per cent of the country's egg supply and have about 25 per cent of the population. There is a shortage of poultry products in the territory. It provides a good market for nearby poultry and for the surplus products from the North Central states. Many large specialized poultry farms are found in North Atlantic states.

The South Atlantic states have about 10 per cent of the laying flocks and 14 per cent of the population. This is a deficit area for eggs. Small farm flocks predominated in the area until the last few years. There is a tendency toward development of large specialized and integrated poultry businesses.

Table 1–4

PRODUCTION OF POULTRY PRODUCTS IN THE UNITED STATES IN 1958 [3]

State and Region	Chickens Raised on Farms (Millions)	Eggs Produced (Millions)	Com. Broilers Produced (Millions)	Turkeys Raised (Thousands)	Hatchery Chick Produced (Millions)
Maine	6.7	662	56.5	113	63.
N. H.	3.8	452	7.9	133	19.7
Vt.	1.8	178	1.0	72	.6
Mass.	4.5	741	14.0	472	28.7
R. I.	.6	87	1.7	28	2.9
Conn.	5.2	724	30.4	225	53.5
N. Y.	10.5	1793	13.6	621	22.9
N. J.	10.7	2433	6.8	171	36.7
Pa.	21.6	3579	42.3	1367	55.6
N. Atlantic	65.4	10649	174.1	3202	313.6
Ohio	14.8	2357	17.2	3063	50.9
Ind.	16.3	2439	44.9	2777	105.2
Ill.	18.0	3014	8.4	1081	50.8
Mich.	10.7	1661	4.7	1043	21.3
Wis.	17.2	2449	19.5	2751	33.8
E. N. Central	77.0	11920	94.8	10715	262.0
Minn.	24.8	3865	4.0	10340	48.6
Iowa	34.1	5091	4.2	6741	68.3
Mo.	17.0	2000	33.9	3226	96.8
N. Dak.	6.0	529		706	3.6
S. Dak.	11.0	1465		667	15.2
Nebr.	13.3	1860	2.3	1052	21.3
Kan.	13.4	1697	2.0	748	17.1
W. N. Central	119.6	16507	46.3	23480	270.8
Del.	1.0	118	94.3	505	82.3
Md.	2.9	393	86.2	319	95.4
Va.	6.1	824	63.5	6404	90.0
W. Va.	2.5	374	27.3	1454	13.4
N. C.	17.1	1828	134.6	1735	131.5
S. C.	6.6	555	17.6	906	24.2
Ga.	17.8	1364	292.1	287	324.0
Fla.	4.7	684	11.3	255	29.9
S. Atlantic	58.5	6140	726.8	11865	790.7
Ky.	8.9	964	18.5	367	22.8
Tenn.	9.7	905	29.1	187	48.0
Ala.	9.4	907	131.6	306	129.3
Miss.	5.5	619	85.4	199	89.4
Ark.	6.0	638	133.3	2381	134.0
La.	3.6	353	20.5	42	19.9
Okla.	6.2	767	6.7	1055	14.1
Tex.	16.1	2305	114.9	3768	136.6
S. Central	65.4	7458	539.9	8305	594.1
Mont.	2.8	238		20	
Idaho	2.4	302	2.8	144	4.2
Wyo.	.6	67		6	.2
Col.	2.3	296	1.2	1255	4.7
N. Mex.	.7	119		75	.07
Ariz.	.9	109	.5	100	4.0
Utah	2.3	369	2.0	2905	3.7
Nev.	.2	18		2	
Wash.	4.5	997	14.9	515	25.8
Ore.	4.6	621	8.3		19.0
Calif.	28.6	4871	47.8	13786	107.2
Western	49.8	8007	77.7	20338	168.87
U. S.	435.8	60681	1659.6	77905	2400.5

[3] U. S. D. A. Preliminary statistics.

Fig. 1-5. A biological laboratory in which chickens are used for testing feeds.

Development of the Poultry Industry

Early development. The poultry industry was brought to America from Europe by the earliest settlers. Small home flocks were started at the time of the establishment of the first permanent homes at Jamestown in 1607. They consisted of a few chickens which were kept to supply the home needs for eggs and meat. The Indians bought or stole birds from the early settlers, and poultry-keeping became common among them during Colonial days.

As villages and towns were established, the nearby home flocks were increased in size. The surplus eggs and meat were sold or exchanged for groceries in the nearby towns. Grain production and the development of transportation facilities encouraged the production of poultry west of the Allegheny Mountains in the early part of the nineteenth century. The development of refrigeration facilities and artificial methods of incubation and brooding were further stimuli for poultry production in the latter part of the century.

Development in recent years. Farms on which the chief source of income was from poultry began to appear early in the present century. The discovery of vitamins and their use in poultry feeding about 1925 revolutionized the poultry industry. Their use has made it possible to raise birds in confinement and at all seasons of the year. Recently, specialized poultry farms have been

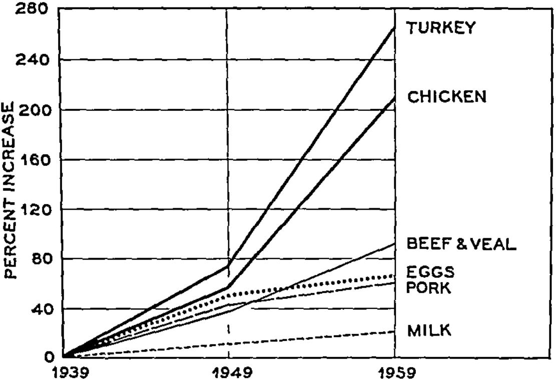


Fig. 1–6. Changes in the production of animal products in the United States.

developed. These include egg, breeding, broiler, pullet rearing, turkey, and duck farms.

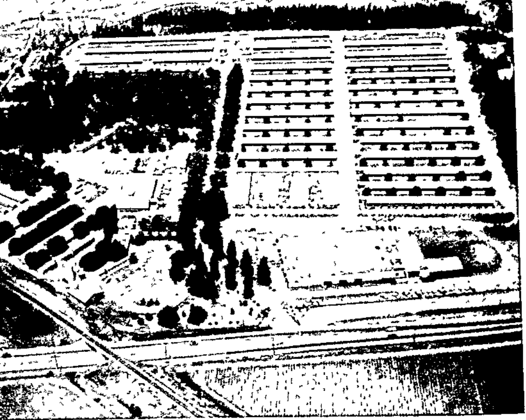
Growth of the poultry industry has been more rapid than the increase in population or the production of the larger farm animals (Fig. 1–6). These changes are typical of those that have taken place in older civilized countries. As population increases, more cereals and small fruits and vegetables are produced and smaller animals, including poultry, replace many of the larger farm animals. Egg production per capita has more than doubled during the last fifty years in spite of the fact that the population has increased two and one-half times during the same period. Most of the increased egg production has been consumed in our own country. A better appreciation of the nutritional value of eggs, better market facilities, development of new uses (Fig. 1–3), and better quality of eggs have created a greater demand for eggs.

The Present Poultry Industry

World distribution. The United States has about one-third of all the chickens and turkeys in the world (Table 1–3) and only about 6 per cent of the people.

Distribution in the United States. The country is usually divided into geographical regions for statistical reports (Tables 1–4 and 5).

The North Central states have about 47 per cent of the total egg production in the United States but only about 30 per cent of the population.



COURTESY KIMBER FARMS, NILES, CALIFORNIA

Fig. 1-7. A large specialized poultry breeding farm.

The South Central states have about 18 per cent of the layers and 17 per cent of the population. Part of the states in the territory have a surplus of poultry products while others do not have enough to meet local needs. Small farm flocks are common in the South Central states.

The Western states have about 13 per cent of the egg production and 15 per cent of the population. There is a shortage of poultry products in the territory. The West Coast states have turned from surplus egg-producing states before World War II to an egg shortage area since the war. The poultry population is small in the Rocky Mountain states. There are many large specialized poultry farms in the West Coast states (Fig. 1–7).

The leading poultry states from the standpoint of the number of eggs produced in 1958 (Table 1–4) were Iowa, California, Minnesota, and Pennsylvania.

Imports and exports. The United States is normally neither a large exporter nor importer of poultry products (Table 1–6). Some dried eggs were imported from China before World War II. During the war period there was considerable expansion of the dried egg business in the United States. In recent years, the United States has exported egg products to European countries, Mexico, Cuba and South America. Small amounts of poultry and eggs have been imported from Canada.

Relative importance of different species of poultry. Chickens constitute more than 95 per cent of all poultry raised (Table 1–7 and Fig. 1–8).

Table 1–5

POPULATION, EGGS AND POULTRY PRODUCTION BY REGIONS, 1958

Region	Population	Egg Prod.	Broiler Prod.	Turkey Prod.	Per Cent Distribution of U. S. Total			
					Population	Eggs	Broilers	Turkeys
	Mil.	Bil.	Mil.	Mil.	Per-cent	Per-cent	Per-cent	Per-cent
North Atlantic....	43.0	10.6	184	3.2	25	18	11	4
E. N. Central.....	35.6	12.1	96	10.7	21	20	6	14
W. N. Central....	15.4	16.4	46	23.5	9	27	3	30
South Atlantic...	25.4	6.1	725	11.9	14	10	44	15
South Central...	20.5	7.4	530	8.3	16	12	32	11
Western.........	25.4	8.0	77	20.3	15	13	5	26
United States...	173.3	60.6	1,660	77.9	100	100	100	100

Table 1–6

UNITED STATES' IMPORTS AND EXPORTS OF POULTRY PRODUCTS [4]

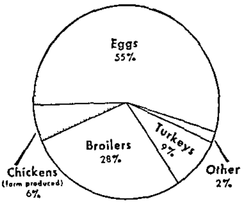
	1937–39	1946–50	1955
Live poultry			
Export (1000 lbs.)..	105	1258	2628
Imports (1000 lbs.). ...	2363	13555	958
Baby chicks..			
Export....			17,759
Imports........	1	360	14
Frozen poultry....			
Export (1000 lbs.).	1991	10,002	24,966
Imports (1000 lbs.)...	370	3785	294
Eggs in the shell			
Export (1000 doz.)	2389	30953	49,725
Imports (1000 doz.).........	360	2228	2,157

[4] *U. S. D. A. Foreign Agriculture Circ. F P E—6–56. 1956.*

Table 1–7

PRODUCTION OF PRINCIPAL SPECIES OF POULTRY IN THE UNITED STATES

Year	Species of Poultry			
	Chickens	Turkeys	Ducks	Geese
	Millions	*Millions*	*Millions*	*Millions*
1909.................				
1919............. ..	473			
1929..........	751	18.5	11.3	4.0
1939..................	803	33.6	12.1	1.2
1947................ .	1028	34.8		
1953..................	1048	60.4	11.1	1.7
1958..................	2086	77.9		



Poultry meat production has gained a higher percentage of the total poultry production over the past few years. Specialized broiler production has been increased while general farm production of chickens has been declining. Turkey production has gained a higher percentage of the total poultry production. Other species of poultry have remained about two percent of the total.

Fig. 1–8. Value of poultry products produced in the United States in 1958. Shaded portions denote home consumption.

The income from chicken eggs is more than that from all types of poultry meat production. The production of broilers and turkeys has increased rapidly during the last fifteen years (Fig. 1–6).

The Future of the Poultry Industry

The growth of the poultry industry in the United States has been rapid in recent years (Fig. 1–6).

The production of poultry products has not reached the saturation point. Consumption is still increasing with about 50 per cent as much poultry (chicken and turkey) as pork being eaten (Table 1–8 and Fig. 1–11).

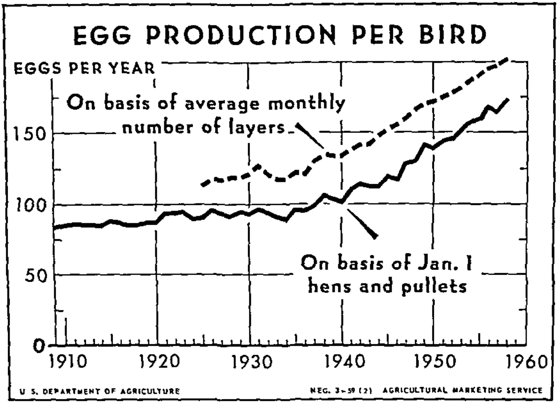
The future expansion of the poultry industry will depend largely on how economically poultry meat and eggs are produced in comparison with other similar groups of foods such as the red meats and dairy products. It will also depend on the new uses developed for poultry products and their convenience as food items.

Growth rate may be faster in the future (Table 1–10). A few birds among the better broiler strains now weigh four pounds at eight weeks of age. Application of genetic principles to poultry breeding will be important for increasing growth rate.

Egg production may be expected to increase in the future (Fig. 1–9). Some chickens among the better egg laying strains now lay more than 300 eggs per year. Application of genetic principles to poultry breeding will be essential for further improvement in egg production.

Feed efficiency may be better in the future (Table 1–10). Young chickens have been grown with less than a pound of feed per pound of gain by the use of high energy rations with low moisture content. The success to be realized with practical rations will depend on the application of chemistry, physiology, and nutrition to the formulation, manufacture, and use of poultry rations.

Housing and equipment of more durable quality will depend on the application of physics, engineering, and physiology knowledge to the construc-



U. S. D. A., A. M. S.

Fig. 1–9. United States average annual egg production per bird.

tion of incubators, brooders, houses, and labor saving equipment (Table 7–9).

Livability improvement may be expected in the future (Table 4–11 and 14). This will depend on bettering of stock and nutrition, a knowledge of physiology, bacteriology, and related biological sciences applied to production, and the use of drugs and vaccines for the prevention of diseases.

Quality of products should be better in the future (Table 4–10). This will depend on bettering of stock, nutrition, and livability, and the use of chemical, microbiological, and food preservation knowledge in the preservation and holding of poultry meat and egg products.

Labor saving devices are being employed to a greater extent in poultry production by the larger operators (Table 7–9). These include automatic feeders, waterers, egg gathering belts (Fig. 7–21), pit cleaners, egg washers, poultry pickers, etc. It is now possible for one man to care for 20,000 to 40,000 broilers or 5,000 to 10,000 laying hens. Poultry processing in modern chain operated plants, has been stepped up to the point where it is possible to process 300 birds per man-hour from live birds to ready-for-the-oven. More production per man-hour may be expected in the future (Fig. 1–12). This should lower the cost of poultry products to consumers, increase consumption, and result in an expanded poultry industry.

Marketing costs may be reduced by applying principles of economics, marketing, business organization, and related sciences to the distribution of poultry products (Tables 12–19, 20, and 21).

Table 1–8

APPARENT CIVILIAN AND PER CAPITA CONSUMPTION OF MAJOR FOOD COMMODITIES [5]

Food Product	Consumption: 1958	1958 as a percentage of: 1935–39	1947–49
Beef, carcass wt. lbs.	152	120	102
Pork, carcass wt. lbs.	60.5	107	88
Fish, edible wt. lbs.	10.0	91	95
Eggs, number	348	116	90
Chicken, ready-to-cook lbs.	28.5	213	152
Turkey, ready-to-cook lbs.	5.6	255	170
Fluid milk and cream lbs.	345	105	96
Butter, lbs.	8.5	50	80
Margarine, lbs.	9.1	314	162
Lard, lbs.	9.5	86	77
Fruits, Fresh wt. Total	92.3	66	70
Vegetables and melons, farm wt. lbs.	130.7	93	88
Sugar, refined, lbs.	97.0	100	102
Wheat flour, lbs.	118	74	86

[5] U. S. D. A. The National Food Situation, NFS-86. 1958.

Table 1–9

POTENTIAL POULTRY AND LIVESTOCK NEEDS IN 1975 COMPARED WITH 1954 [6]

Product	Per Cent increase from 1951–1952 production
Eggs	48
Broilers and chickens	60
Turkeys	48
Milk	33
Cattle and calves	50
Hogs	42
Sheep and lambs	25
All animal products	45

[6] *U. S. D. A., A. M. S* and *A. R. S.* estimates.

Table 1–10

INCREASE INEFFICIENCY IN BROILER PRODUCTION TO 3 POUND WEIGHT [7]

Observation	Year 1930	1955	1960 (Estimate)
Pounds of feed	15	8	6
Pounds per pound of broiler	5	3	2
Weeks to reach 3 lb. weight	15	9	8

[7] Feedstuffs. October, 1959

U. S. D. A.

Fig. 1–10. The Seventh World's Poultry Congress, held in Cleveland, Ohio, with an attendance of more than 800,000. Top left, part of the exhibit buildings. Top right, viewing one of the nutrition exhibits. Center, the Japan exhibit. Bottom, part of the U. S. D. A. exhibit.

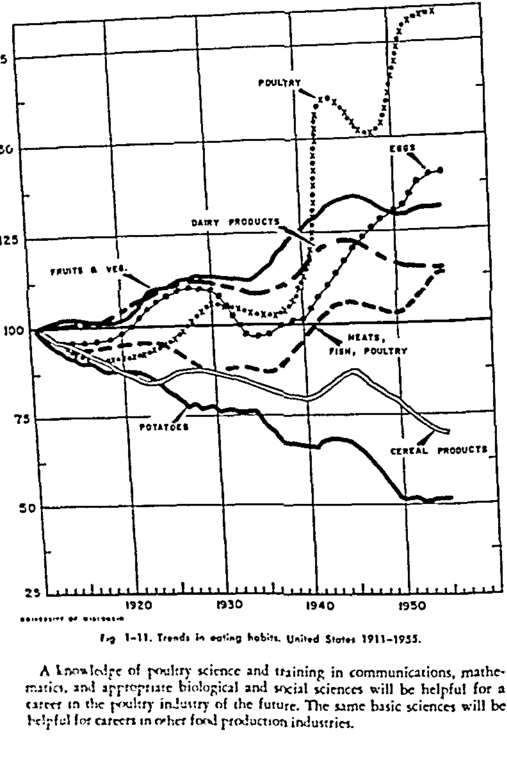
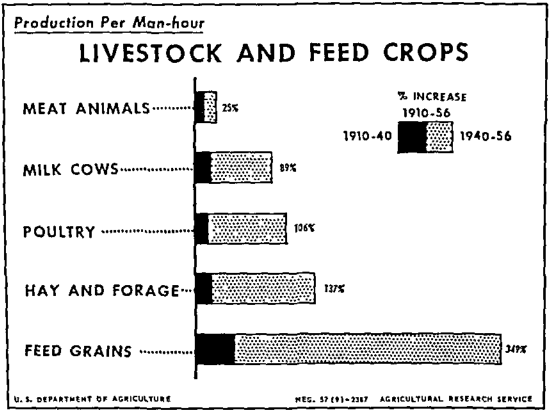


Fig. 1-11. Trends in eating habits. United States 1911–1955.

A knowledge of poultry science and training in communications, mathematics, and appropriate biological and social sciences will be helpful for a career in the poultry industry of the future. The same basic sciences will be helpful for careers in other food production industries.



U. S. D. A., P. M. A.

Fig. 1–12. Changes in production of agricultural products per man-hour.

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Chapter 2

Classes, Breeds, and Varieties of Chickens

The Origin of the Chicken

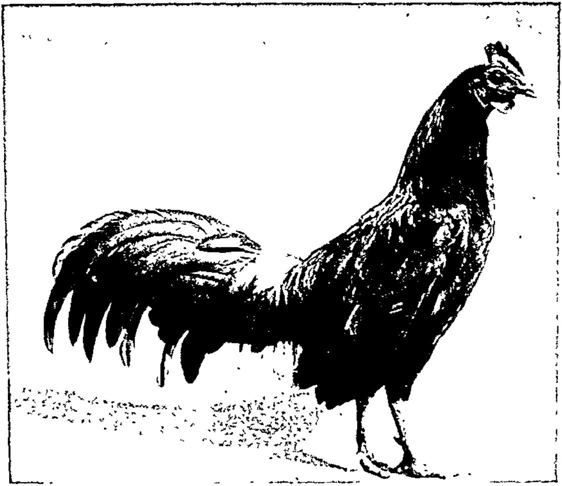
FOR MORE THAN 5,000 YEARS the domesticated fowl has been one of man's benefactors. It is improbable that all the present-day varieties sprang from a common origin. The habits of the varieties in the Asiatic class indicate an ancestry which roosted on the ground and nested on a mound of earth. Such breeds as the Leghorns probably had tree-roosting ancestors. Authorities agree quite generally that the red jungle fowl, *Gallus bankiva* (Fig. 2–1), was one of the ancestors. Wild chickens of the *Gallus* genus are still found in the jungles of southeastern Asia. More recent investigations suggest that at least four species of the jungle fowl may have contributed to the development of the domestic fowl.

Development of the Modern Breeds and Varieties of Chickens

There are many biological differences between the two-pound jungle hen which laid only a few eggs per year and the modern hen which lays 300 eggs or a present-day thirteen-pound Jersey Giant. How has such progress been made? Heredity has been the force which nature and man have used to develop the domesticated fowl. Fortunately there has been much variation so that man and nature could make selection. Natural selection both before and after domestication developed a more vigorous bird.

Cockfighting. Early references to cockfighting suggest that this was once one of the principal uses of the male of the species. This sport accelerated the law of the survival of the fittest and did much to develop the vigor and vitality of the species. It also served the very useful purpose of giving wider distribution to the domestic fowl as cockfighting spread throughout the world.

Meat production. If the meat of the chicken had not possessed such delicious edible qualities, it is not likely that the so-called meat and general-purpose breeds would have been developed. However, man soon learned the value of the chicken as a source of food and he selected the larger and better-fleshed birds so that his meat supply might be increased. This type of selection increased the size of certain breeds.



COURTESY NEW YORK ZOOLOGICAL GARDENS

Fig 2–1. Gallus bankiva, one of the probable ancestors of the domestic fowl. The male weighs about two and one-half pounds.

Exhibition qualities. The "Golden Era" of the fancier was from 1870 to 1920 when he reigned almost supreme. The trap nest had not yet caused the worship of egg records; fancy feathers and body form remained the goal of every true breeder. These breeders, by breeding for uniform type and definite color patterns, did much to establish the Standard breeds and varieties. Many beautiful color patterns were developed and excellent type birds were established. While in some cases vitality may have been lowered at the expense of exhibition quality, the exhibition breeders made very definite and important contributions to the development of the chicken.

Egg production. The invention of the trap nest and the discovery of the laws of inheritance, together with their application to poultry breeding, were major contributions to the development of high-producing strains of poultry. The trap nest was a practical device for determining the number of eggs the individual bird would lay; and those eggs could be identified, and such characteristics as size, shape, color, and interior quality could be determined. Poultry breeders are today applying the laws of heredity to their breeding problems and using the trap nest to identify their breeding stock.

The American Poultry Association

The American Poultry Association, organized at Buffalo, New York, in 1873, has for its objective the protection and promotion of the Standard-bred poultry industry. The association issues the American Standard of Perfection, which describes the respective varieties, breeds, and classes of poultry which are recognized as Standard-bred.

The association has the responsibility of recognizing new breeds and varieties of poultry. Breeds or varieties which the association considers obsolete are dropped from the list of Standard-bred poultry.

Standard Classification

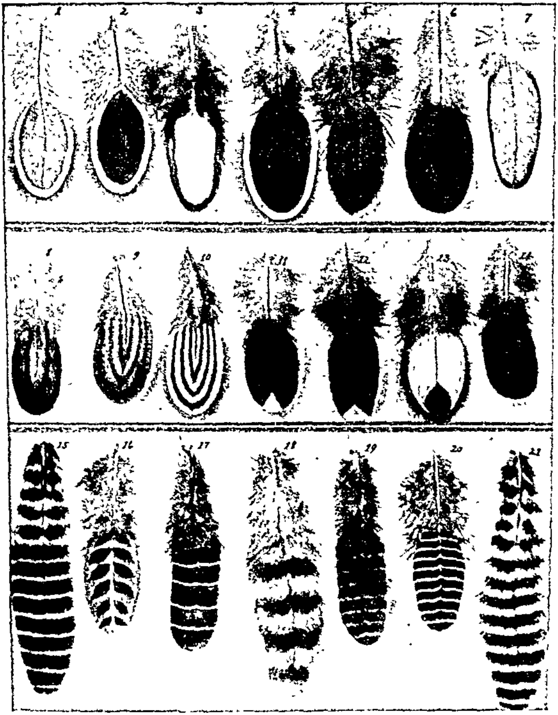
Breeds and varieties admitted to the Standard must possess distinctive type and color patterns and be sponsored by at least five members of the association who are active breeders of the variety.

The term *class* is used generally to designate groups of Standard breeds which have been developed in certain regions; thus, the class names—American, English, Asiatic, etc. The distinctive *breed* differences are primarily those of body shape and size. The color pattern (Fig. 2–2) and shape of comb (Fig. 2–3) distinguish the different *varieties*. Varieties in the same breed may have an entirely different ancestry. For example, the Barred Plymouth Rocks originated from the crossing of a hawk-colored cock (probably a Dominique) with Black Cochin hens, with possibly some Spanish and Dorking blood added later, while the Buff Plymouth Rocks were selected in 1889 from red fowls in the vicinity of Westport, Massachusetts. A *strain*, as defined in poultry genetics, is chicken-breeding stock bearing a given name and produced by a breeder through at least five generations of closed-flock breeding.

American Class

The breeds and varieties in this class were developed by American breeders to serve the general purpose of supplying both meat and eggs. All varieties in this class possess certain common characteristics; for example, they have yellow skin, nonfeathered shanks, and red earlobes (Fig. 2–4) and all lay brown-shelled eggs except the Lamonas, which lay white-shelled eggs. The chart on page 516 lists the varieties and breeds in this class and gives their more important characteristics.

Plymouth Rocks. The oldest and, until recent years, the most popular variety of this breed was the Barred Plymouth Rock, which originated in Connecticut from a Dominique-Black Cochin cross made in 1865. It was admitted to the first Standard published in 1874. The Barred and White (Fig. 2–5) varieties are the two most popular varieties of this breed. In recent years there has been an increasing demand for White Plymouth Rocks for broiler production.



COURTESY "AMERICAN POULTRY JOURNAL"

Fig. 2–2. Feather patterns of the domestic fowl. The above feathers are from the following varieties: 1, Buff-Laced Polish; 2, White-Laced Red Cornish; 3, Silver-Laced Wyandotte; 4, Columbian varieties; 5, Golden-Laced Wyandotte; 6, Blue varieties; 7, Golden Sebright Bantam; 8, Dark Cornish; 9, Partridge varieties; 10, Silver-Penciled varieties; 11, Ancona or Mottled Houdan; 12, Speckled Sussex; 13, Silver-Spangled Hamburg; 14, Golden-Spangled Hamburg; 15, Dark-Barred Plymouth Rock; 16, Buttercup; 17, Silver Campine, 18, Dominique; 19, Golden-Pencilled Hamburg; 20, Silver-Penciled Hamburg; 21, Light-Barred Plymouth Rock.

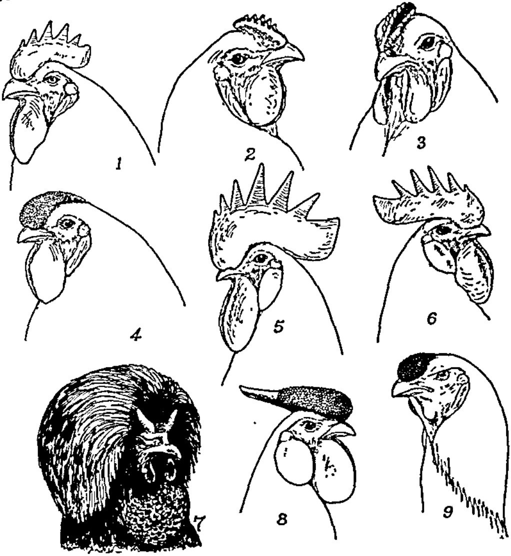
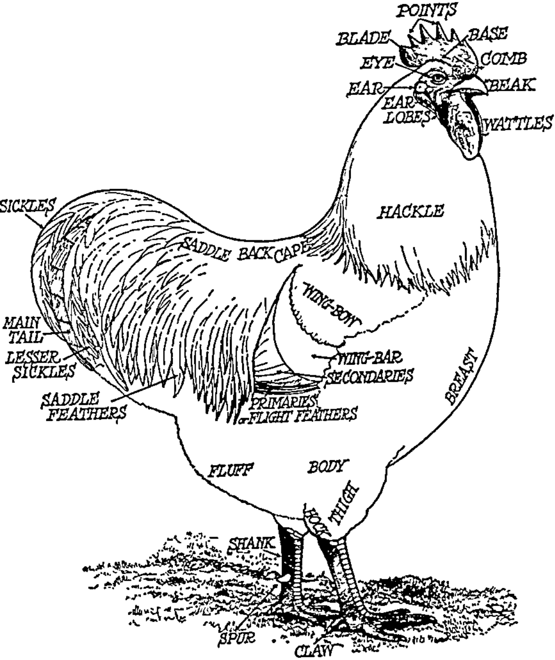


Fig. 2–3. Male heads showing different types of combs. 1, Single; 2, Pea; 3, Pea; 4, Rose; 5, Single; 6, Single; 7, V-shaped; 8, Rose; 9, Strawberry.

Rhode Island Reds. The Rhode Island Reds were not developed by the fancier but were developed by the farmers of the Little Compton district of Rhode Island. The original crosses were red Malay Games and reddish-colored Shanghais, followed by the introduction of the blood of many other breeds, such as the Brown Leghorn, Cornish, and Wyandotte. The early development of this breed was for utility purposes. Later it became a fancier's fowl as well. Today some strains are kept for egg production.

Wyandottes. The Wyandottes have had waves of popularity in America. Today the White variety is the most popular Wyandotte. It has been handicapped by small-egg size and relatively poor hatching results. There are very few breeders of Wyandottes at present.

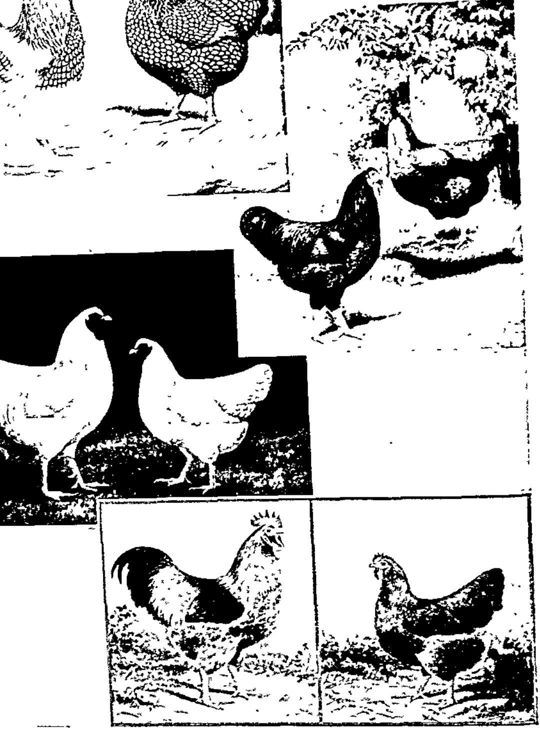


U. S. D. A.

Fig. 2–4. Nomenclature chart of the male chicken.

New Hampshires. This breed developed from the Rhode Island Red stock which was introduced into New Hampshire from Rhode Island and Massachusetts. For more than twenty-five years the poultrymen of New Hampshire selected their Reds for such production qualities as early maturity, early feathering, large-egg size, and good meat type, apparently omitting color of plumage from consideration. There resulted fowls possessing distinctive characteristics. Their color pattern was lighter than that of exhibition Rhode Island Reds but not unlike some strains of Reds in which the breeders have emphasized egg production and let color "take care of itself."

Other breeds. The other breeds and varieties in the American class



COURTESY · POULTRY TRIBUNE

Fig. 2-5. Some breeds of the American Class. Top left, Silver-Laced Wyandottes. Top right, Single-Comb Rhode Island Reds Center, White Plymouth Rocks. Bottom, New Hampshires.

(p. 22) have not been generally adopted by the public, and therefore few flocks of these varieties are found on farms in the United States. These breeds include the Dominiques, Javas (Black and Mottled), Chantecler (White and Partridge), Jersey Black Giants, Jersey White Giants, and Lamonas.

Mediterranean Class

This class contains those breeds which had their origin near the Mediterranean Sea—namely, Leghorns (Italy), Minorcas (Minorca Island), Spanish (Spain), Blue Andalusians (Andalusia, Spain), Anconas (Italy), and Buttercups (Sicily). The breeds in this class are characterized by white earlobes, relatively large combs, nonbroodiness, early maturity, nervous disposition, and production of white-shelled eggs. *A list of all the breeds and varieties in this class is given on page 517.*

Leghorns. This breed (Fig. 2–6) is popular in America. The popularity of this breed rests upon its reputation as an egg producer. While there are thirteen Standard varieties of Leghorns, the only one that has gained public favor is the White.

Minorcas. Five varieties of Minorcas are found in the United States—namely, Black (Single- and Rose-Comb), White (Single- and Rose-Comb), and the Single-Comb Buff.

Anconas. Since the Standard description of the type of this breed does not differ from that of the Leghorn, it appears that the Anconas might very well have been called mottled Leghorns. The breeders of Anconas have not been active in developing their ability as producers of eggs, and as a result the White Leghorn breeders have supplied the demand for high-producing birds which lay large eggs, and the Anconas have gradually decreased in popularity.

Other breeds. The other breeds in this class are the White-Faced Black Spanish, Blue Andalusians, and Buttercups. These breeds have not gained the favor of the American farmers or poultrymen because other breeds possessing similar characteristics and producing white-shelled eggs have been more efficient producers of eggs which satisfy American market requirements.

English Class

The breeds of English origin include the Orpingtons, Cornish, Australorps, Dorkings, Sussex, and Redcaps. They all have white skin except the Cornish, which has yellow skin. The breeds in this class have red earlobes and all except the Dorkings and Redcaps lay brown-shelled eggs. They possess good meat quality but some markets prefer poultry with yellow skin and therefore discriminate against these white-skinned breeds. The Cornish are poor layers, but they possess excellent meat type, having particularly well-developed breasts.

Orpingtons. The Orpington name came from the town of Orpington in Kent County, England, the home of William Cook, who developed Black Orpingtons. Of the four varieties—Buff, White, Blue, and Black—the Buff Orpington (Fig. 2–7) is the only variety which has widespread distribution in the United States, but its popularity has declined in recent years.

Cornish. The American Standard describes three varieties of Cornish.

Dark, White, and White-Laced Red. The Cornish, formerly called the Cornish Indian Game, are very closely feathered and have unusually compact bodies. In recent years the Cornish have been used to develop white males for crossing to produce better meat type broilers.

Dorking. The Standard recognizes three varieties: Silver-Gray, White, and Colored. Columella, a Roman agricultural writer of the first century A.D., no doubt referred to the ancestor of the Dorking fowl when he stated: "Those are believed to be the best breed that have five toes."

Sussex. Of the three Standard varieties—Speckled, Red, and Light—only the Speckled Sussex has met with favor in the United States, and of this variety there are only a few breeders. The Sussex are splendid meat birds and have been prized as market poultry in England for the past two hundred years. The Light Sussex is the most popular variety of this breed in Canada and England.

Australorps. This breed, as its name indicates, is an Australian Orpington. The Black Orpingtons which were taken to Australia were there bred into a very productive fowl and established at one time the world's annual egg record in an egg-laying contest. Black Australorp cockerels are used for crossing with White Leghorns to produce Austra-whites.

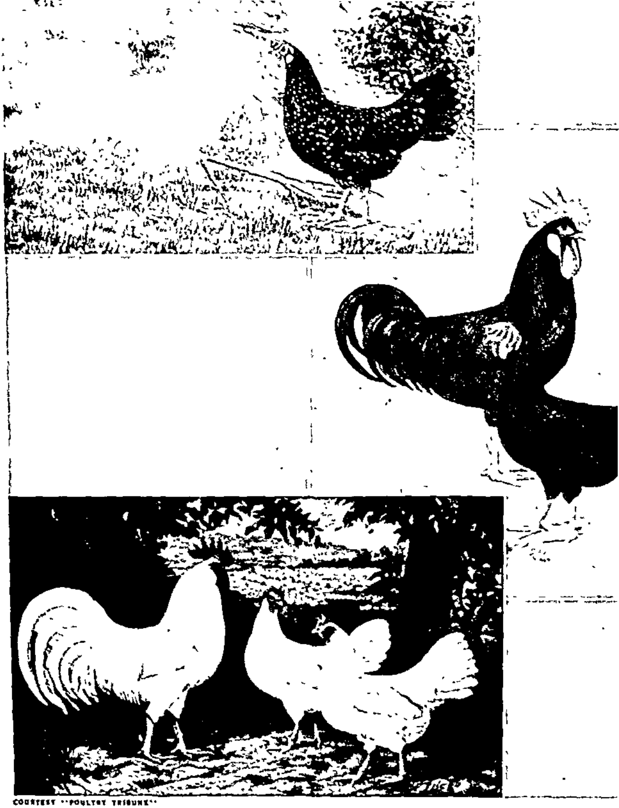
Redcaps. This breed is seldom found in the United States. It apparently has only a limited following in England. The Redcaps produce eggs with white shells.

Asiatic Class

The breeds of Asiatic origin have made valuable contributions to the blood lines of breeds in the American and English classes. Apparently the descendants of the jungle fowl and the Malay fowl were not interbred until they reached England and America in the nineteenth century. The large breeds imported into these countries from China and India evidently possessed plenty of size, stamina, and egg-laying ability. This stock made valuable contributions in the development of the American breeds and in this manner rendered the poultry industry of America a distinct service. However, their popularity as pure breeds has gradually decreased.

Brahmas. This breed (Fig. 2–8) came originally from the Brahmaputra district of India. The Gray Chittagongs still found in this part of India are quite similar to the modern Brahma. The first specimens imported to America in 1846 and England in 1853 were light in color. The varieties Light and Dark were developed in America and England. The decline in popularity of the Brahmas was probably due to the fancier's overemphasis on feather development and neglect of production qualities.

Cochins. When first imported to America about 1847, the fowls which later came to be known as Cochins were called Shanghais. Their popularity was greatly enhanced in England by the interest manifested by Queen Victoria in exhibiting them at the Royal Dublin Society Show in April, 1846. They are reported to have created the "hen fever" and started the chicken fancy



COURTESY "POULTRY TRIBUNE"

Fig. 2–6. Some breeds of the Mediterranean Class. Top, Single-Comb Anconas. Center, Single-Comb Black Minorcas. Bottom, Single-Comb White Leghorns.

in America. The original importations were various shades of buff color and were said to be the first buff-colored fowls seen in England and America.

The popularity of the Cochins waned when the public discovered that they were poor producers and very broody. This is an example of what improper

breeding can do to destroy a breed. If the breeders had bred for nonbroodiness and egg production instead of concentrating effort on profuse and loose feathering, this breed, which had an auspicious beginning, might have remained one of the popular breeds of America.

Langshans. The Black Langshan was taken to England from China in 1872 and was imported to the United States from England. Though excellent flocks of Langshans were found a few years ago, their popularity has also declined. Artificial standards for the long-legged type injured their economic quality and contributed to their present unpopularity.

Other Standard Classes

The American Standard of Perfection describes several classes of chickens which have but little economic importance in the United States. Many of the breeds in these classes are of interest to fanciers only, while others are popular breeds in their homelands.

Polish class. The "Paduan" fowl which was described in Italy as early as 1600 possessed characteristics quite similar to the Polish breed. The Polish (Fig. 2–9) are crested and have an unusual skull structure. This peculiar skull formation suggests a crested jungle fowl ancestry. The Polish in the United States are a fancier's fowl.

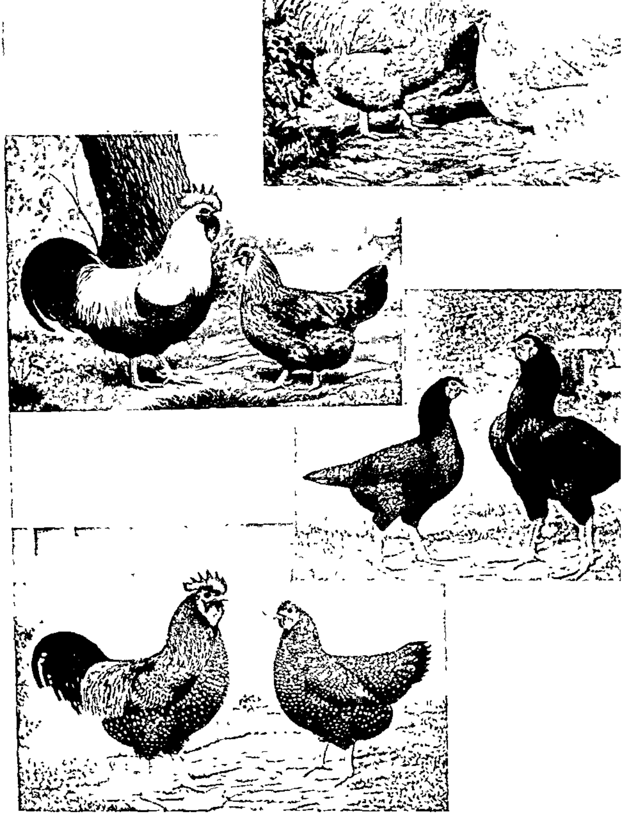
Hamburg class. The Hamburgs originated in Holland. When first introduced into England and America they were popular with the fanciers, and at one of the early Boston shows three hundred specimens of this breed were exhibited. They remain a fancier's fowl and therefore are of little economic importance to the poultry industry of the United States.

French class. The French breeds and varieties described in the American Standard are Houdans (Mottled and White), Crevecoeurs (Black), LaFleche (Black), and the *Faverolles* (Salmon). These breeds are noted for the quality of their meat. The Houdans are sometimes found in the show room in the United States but other breeds are rarely seen even in these poultry exhibitions.

Continental class. The American Poultry Association recognizes only the Campines (Silver and Golden) and the Lakenvelders. These fowls have been bred in Belgium and Germany for several centuries. The modern Campine is reported to be half Campine and half Braekel. Though similar to the Leghorn in many respects, this breed has not been popular in America.

Game and Game Bantam class. The modern Game fowl is an exhibition bird and is raised for ornamental purposes. Though cockfighting is outlawed in the United States, the sport remains one of the gambler's devices for stimulating betting, and it is said that outside the law the sport flourishes in some communities. The English Pit Game is used for this purpose.

Oriental class. As the class name and the names of these breeds (Sumatra and Malay) indicate, they come from southeastern Asia. The Cubalaya was developed in Cuba.



COURTESY "POULTRY TRIBUNE"

Fig. 2–7. Some breeds of the English Class. Upper left, Silver-Gray Dorkings. Upper right, Buff Orpingtons. Lower left, Speckled Sussex. Lower right, Dark Cornish.

Ornamental Bantams. The Bantams are excellent pets for children and ideal for the true fancier who desires to try his hand at shaping the type and arranging the color designs of his chosen variety.

Non-Standard Breeds and Varieties

While there are many varieties of chickens which have not been admitted to the American Standard, only those which have attracted the public because of some peculiar character or their economic possibilities will be discussed here.

Yokohama. This long-tailed Japanese breed is of interest because of the unusual tail development. The sickle feathers sometimes attain a length of from fifteen to twenty feet.

Araucana. This breed, first reported in 1914 from South America, is often rumpless, has a peculiar muff development, and lays eggs with blue shells (but often containing some brown or red pigment).

Naked-necked fowl. This breed, referred to as the "Turken," has a bare neck.

Crossbred poultry. In recent years the crossing of purebred breeds of chickens has received considerable attention by poultrymen. Some of the more common crosses used are Cornish with White Rocks or New Hampshires, Black Australorps with White Leghorns, and White Leghorns with Rhode Island Reds.

In-crossbred poultry. In-crossbreds are produced by crossing inbred lines. The mating of close relatives for several generations is necessary to produce an inbred line (p. 92). Such lines are more uniform genetically than non-inbred lines. When inbred lines are crossed, the performance of their offspring is more uniform than random mated non-inbred lines. Thus, by testing and reproducing for sale only the better combinations of inbred lines, the performance of in-crossbreds as a group is improved. The principle is similar to that of producing hydrid corn.

Choosing a Variety to Raise

That there is a great diversity of opinion as to the best variety of poultry to raise is evidenced by the 189 varieties which the American Poultry Association recognizes. Each variety has its advocates. The Bantams surely have a place as pets, the Games and Game Bantams are the fanciers' creation, the breeds in the Mediterranean class are preferred because of their heavy production of large white-shelled eggs, and the breeds of the English class and the American class are good producers of eggs and meat. Each color pattern has its champions. The beginner will do well to observe the successful poultryman or breeder and start with some of the same stock. Many beginners have permitted some minor and probably fancy point to influence their selection of a variety which later caused the failure of their poultry enterprise.

Poultry producers have in recent years become more discriminating in their selection of varieties of poultry to raise. They are paying more attention to the productivity of the stock they purchase and placing less emphasis on color of feathers and other minor characters. This trend is shown in Table 2–1.

COURTESY "POULTRY TRIBUNE"

Fig. 2–8. Breeds of the Asiatic Class. Top, Black Langshans. Center, Buff Cochins. Bottom, Light Brahmas.

Results in official egg-laying contests. The reports from the official egg-laying contests (p. 514) should be of help to persons selecting a variety to raise. Table 2–2 presents a summary of the egg production of the principal entries in the official egg-laying contests of the United States in the years of 1957–58. It is evident from these results that only a few varieties remain

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Table 2–1

BREED DISTRIBUTION IN HATCHERY SUPPLY FLOCKS IN THE NATIONAL POULTRY IMPROVEMENT PLAN[1]

Observation	Year	
	1957–58	1941–42
Number of states	47	33
Number of birds under supervision	35,588,558	10,712,027
Cross-mated	*57.7%*	*2.0%*
White Leghorn	17.0	24.1
White Rock	10.1	15.6
Incross-mated	*8.4*	—
New Hampshire	3.2	21.2
Rhode Island Red	1.7	12.5
Barred Rock	0.7	16.2
Other	1.2	8.4

[1] U. S. D A., A. R. S. 44-2. 1958.

popular and most productive.

Random sample tests. In recent years less biased methods for measuring the productivity of poultry stocks have been developed. The most widely publicized of these have been the random sample tests (p. 514). These tests are conducted for egg, broiler, and turkey production.

Random sample egg laying tests. Random sample tests designed to measure the egg production of different stocks have been established in several states (p. 514). Information from these tests includes not only the number and size of eggs, which was about all the Standard Egg Laying Tests reported, but also egg quality measurements, observations, mortality, feed efficiency, and income over feed and chick costs. These tests provide the public with information essential for selecting egg producing stocks.

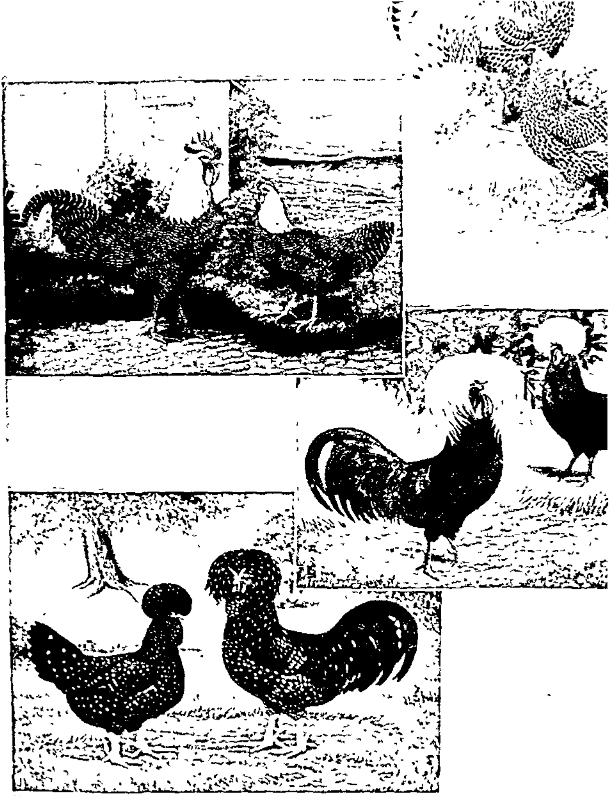
On-the-farm tests. Iowa has developed an on-the-farm test which offers even better criteria for comparing egg stocks. This test evaluates stock on the basis of ten pens distributed over several locations and managements.

Broiler tests. Tests designed to determine the meat production qualities of different meat stocks have been established in some states (p. 515). Some of these tests also measure the reproductive performance of the parental stock.

Random sample turkey tests. Random sample turkey tests have been developed in a few states (p. 515). These tests attempt to measure the meat production qualities of turkeys including feed efficiency and mortality.

U. S. Record of Performance summaries. The United States Department of Agriculture has in recent years issued an annual summary giving the results of records made on the breeders premises under U.S.R.O.P. supervision. This information should also be quite helpful to the beginner looking for a variety of chickens to raise (Table 2–3).

The poultry raiser should select the most productive strains for his poultry



COURTESY "POULTRY TRIBUNE"

Fig. 2–9. Some breeds of the Continental European classes. Upper left, Silver Campines. Upper right, Silver-Spangled Hamburgs. Lower left, Mottled Houdans. Lower right, White-Crested Black Polish.

enterprise. The broiler grower needs a bird that is efficient in producing poultry meat at an early age, whereas the general farmer very likely wants a general-purpose breed that lays well. Those who specialize in egg production prefer the high egg-producing strains.

Table 2–1

BREED DISTRIBUTION IN HATCHERY SUPPLY FLOCKS IN THE NATIONAL POULTRY IMPROVEMENT PLAN[1]

Observation	Year	
	1957–58	1941–42
Number of states	47	33
Number of birds under supervision	35,588,558	10,712,027
Cross-mated	57.7%	2.0%
White Leghorn	17.0	24.1
White Rock	10.1	15.6
Incross-mated	8.4	—
New Hampshire	3.2	21.2
Rhode Island Red	1.7	12.5
Barred Rock	0.7	16.2
Other	1.2	8.4

[1] U. S. D. A., A. R. S. 44-2. 1958.

popular and most productive.

Random sample tests. In recent years less biased methods for measuring the productivity of poultry stocks have been developed. The most widely publicized of these have been the random sample tests (p. 514). These tests are conducted for egg, broiler, and turkey production.

Random sample egg laying tests. Random sample tests designed to measure the egg production of different stocks have been established in several states (p. 514). Information from these tests includes not only the number and size of eggs, which was about all the Standard Egg Laying Tests reported, but also egg quality measurements, observations, mortality, feed efficiency, and income over feed and chick costs. These tests provide the public with information essential for selecting egg producing stocks.

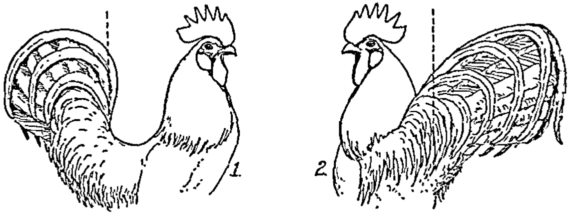
On-the-farm tests. Iowa has developed an on-the-farm test which offers even better criteria for comparing egg stocks. This test evaluates stock on the basis of ten pens distributed over several locations and managements.

Broiler tests. Tests designed to determine the meat production qualities of different meat stocks have been established in some states (p. 515). Some of these tests also measure the reproductive performance of the parental stock.

Random sample turkey tests. Random sample turkey tests have been developed in a few states (p. 515). These tests attempt to measure the meat production qualities of turkeys including feed efficiency and mortality.

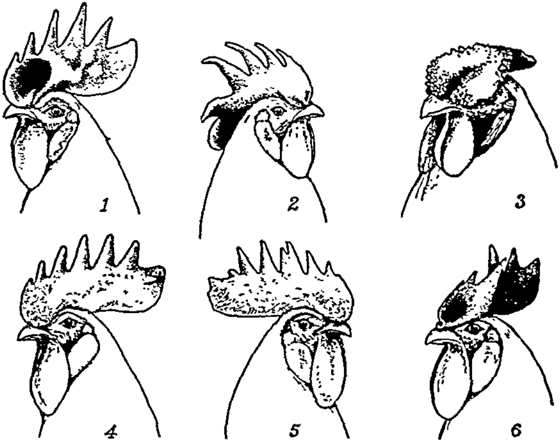
U. S. Record of Performance summaries. The United States Department of Agriculture has in recent years issued an annual summary giving the results of records made on the breeders premises under U.S.R.O.P. supervision. This information should also be quite helpful to the beginner looking for a variety of chickens to raise (Table 2–3).

The poultry raiser should select the most productive strains for his poultry



U. S. D. A.

Males with defective tail carriage: 1, squirrel; 2, wry.



U. S. D. A.

Fig. 2–10. Male heads showing defective combs: 1, thumb mark; 2, lopped (single); 3, hollow center; 4, side-spring; 5, uneven serrations; 6, twisted.

Exhibiting Poultry

Because of the shift in emphasis from the exhibition ideal to the utility goal, the exhibition of poultry has almost become a lost art.

Birds sent to shows should be placed in large coops where they have plenty of feed. Unless water can be placed in containers in the coops so that there is

Table 2–2

PRODUCTION SUMMARY OF ENTRIES WITH 90 OR MORE BIRDS IN OFFICIAL EGG LAYING TESTS FOR 1957–58 [a]

Breed	No. of birds entered	Points per bird	Eggs per bird	Per cent mortality	Average egg size oz. 1 doz.
White Leghorn	1781	255.36	246.15	9.10	25.24
Rhode Island Red	481	252.93	239.74	7.48	26.12
Crossbred	728	249.91	236 48	8 52	26.21
White Plymouth Rock	247	221.41	212.02	8.10	26 01
Barred Plymouth Rock	156	230 69	222.37	13.46	25.90
Incross-bred	78	271.13	256.56	3.85	25.59
Random Breds	52	195.54	202.11	9.62	24.04

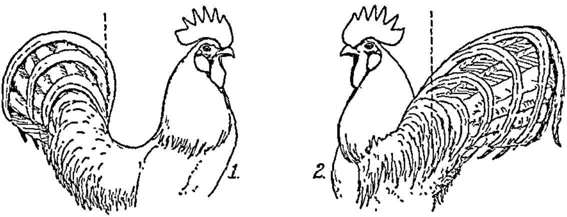
[a] Council of American Poultry Tests. Report 20.

Judging Poultry

The judging of poultry for exhibition quality, though not emphasized as much as it was twenty-five years ago, is important and should be understood by students interested in poultry. Although the emphasis has been shifted to utility and the demand for fancy feathers has decreased, breed type and the more fundamental exhibition qualities should be preserved in the so-called production strains.

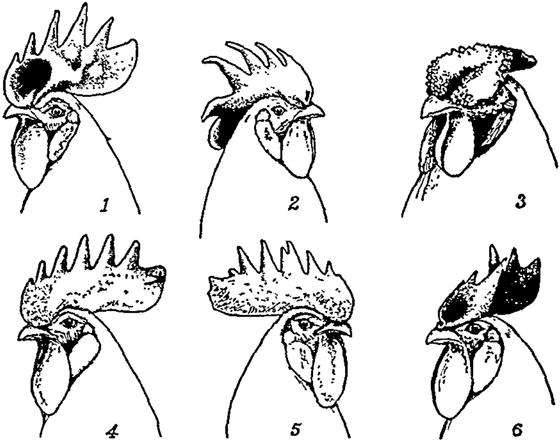
SCALE OF POINTS USED IN JUDGING VARIETIES FOUND IN THE AMERICAN, MEDITERRANEAN, ENGLISH, AND ASIATIC CLASSES

	White		Solid Color Other Than White		Parti-Colored	
	Shape	Color	Shape	Color	Shape	Color
1. Symmetry	4	...	4	...	4	...
2. Weight or size	4	...	4	...	4	...
3. Condition and vigor	10	...	10	...	10	...
4. Comb	5	...	5	...	5	...
5. Beak	2	1	2	1	2	1
6. Head	3	1	3	1	3	1
7. Eyes	2	2	2	2	2	2
8 Wattles	2		2		2	
9. Ear lobes	2	2	2	2	2	2
10. Neck	3	3	2	4	1	5
11. Wings	5	3	4	4	3	5
12. Back	8	4	7	5	6	6
13. Tail	5	3	4	4	4	4
14. Breast	7	3	5	5	5	5
15. Body and fluff	5	3	5	3	4	4
16 Legs and toes	5	3	5	3	5	3
	72	28	66	34	62	38



U. S. D. A.

Males with defective tail carriage: 1, squirrel; 2, wry.



U. S. D. A.

Fig. 2–10. Male heads showing defective combs: 1, thumb mark; 2, lopped (single); 3, hollow center; 4, side-spring; 5, uneven serrations; 6, twisted.

Exhibiting Poultry

Because of the shift in emphasis from the exhibition ideal to the utility goal, the exhibition of poultry has almost become a lost art.

Birds sent to shows should be placed in large coops where they have plenty of feed. Unless water can be placed in containers in the coops so that there is

little danger of the bird or coop becoming soiled by it, some succulent feeds should be placed in the coop instead of water. If convenient, the owner of the birds should attend the show and carefully groom the birds before they are judged and be present to show them to interested spectators and prospective customers.

Many breeders have abandoned the exhibition poultry shows because of the danger of introducing disease back in their flocks. The shows should bar all diseased birds and take all practical sanitary measures to prevent any outbreaks of disease during the show. All birds returned to the breeders' premises should be kept away from the flock for two weeks. Some breeders make it a policy to sell all birds exhibited and never return them to their flocks.

The tendency in poultry exhibitions is to show not only the live birds but to exhibit their products, such as eggs, chicks, and dressed birds. If the hazards of disease are not eliminated, poultry shows may ultimately become exhibits of poultry products.

IMPORTANT GENERAL DISQUALIFICATIONS

Weight. Leghorn and Ancona males more than one and one-half pounds and females more than one pound below Standard weight. All other specimens except Bantams more than two pounds underweight.

Shape. Deformed back or beak. Split or slipped wing. Wry or squirrel tail (Fig. 2–10). Crooked breastbone in turkeys. Twisted feather in wing or tail. Single combs lopped, split, or having a side sprig. Rose combs obstructing sight or without a spike. Combs foreign to the breed. Feathers on shanks or feet of any variety required to have unfeathered shanks. Decided bowlegs or knock-knees.

Color. Positive enamel white in the earlobes of the American, Asiatic, and English varieties except Dorkings, Redcaps, and Lamonas. Positive enamel white in the face of all Mediterranean cockerels and pullets except the White-Faced Black Spanish. Shanks or feet of color foreign to the breed. Red or yellow in the plumage of any black variety. Foreign color in any white variety except slight gray ticking.

Table 2–3

EGG PRODUCTION OF THE STOCKS ENTERED IN U.S.R.O.P. 1957–58 FROM U.S.R.O.P. SUMMARY

Variety	No Flocks	Range of Percentage Qualifying	Range of Average Egg Production	
			10-months Per Cent Prod.	365 Days No Eggs
Single Comb White Leghorns	16	0–87 8	46 4–76.7(7)[a]	178–242.5(8)
Rhode Island Reds	11	35.7–89.6	47.5–74.9(8)	217–262(2)
White Rocks	8	38.7–81.5	49.7–66.4(6)	203–228(2)
New Hampshire	2	52 2–75.2	55.4[b]–66.7(2)	202.5–243.5[c](2)

[a] All numbers in this report in parentheses indicate the number of flocks reported.
[b] Figured from report of 365 day production.
[c] Figured from report on the 10 month percentage of production.

Fig. 2–11. Kansas State poultry judging team, winners in the Chicago contest, 1958.

The American Standard of Perfection should be consulted for the detailed description of all Standard varieties and for a complete list of all defects and disqualifications.

Poultry-Judging Contests

The judging of poultry by students of poultry husbandry has been encouraged during recent years by judging contests for 4-H Club members, vocational agricultural students, and college students.

In many colleges of agriculture, students interested in poultry judging compete in contests sponsored by poultry clubs and departments of poultry husbandry. Regional contests (East, South, and Midwest) are generally held each year. The Eastern Contest was started in 1915 and the Midwest Contest in 1921. The latter has become more of a national contest with more than twenty teams generally entered. This contest includes the following: placing birds for egg production and for breeders, grading eggs, dressed birds, and live market birds.

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Chapter 3

The Anatomy and Physiology of the Chicken

General Characteristics

THE CHICKEN may be considered as a delicate, sensitive, and highly-geared organism. A knowledge of its structures, their functions and operation, is necessary in order to understand the bird's needs and care.

Structural peculiarities. Birds are just above the reptiles in the scale of animal development (Fig. 1–1). They are warm-blooded and covered with feathers, while reptiles are cold-blooded and usually covered with scales or horny plates. The scales on the shanks and toes of birds are evidence of their reptilian ancestors. Birds have compact bodies, light skeletons, and well-developed wings and legs, adapted for flying or running.

Intensity of life. Birds are active, nervous, and alert in comparison with their slow-moving relatives, the reptiles. The nervous system is highly developed and the senses of sight and hearing are keen. Food is carefully selected and quickly and thoroughly digested. Oxidation takes place quickly, and a normal temperature of 105° to 109.5° F. is maintained.

Body systems. The body of the chicken is composed of groups of tissues and organs which carry on the body processes (Fig. 3–1).

The Body Covering or Exoskeleton

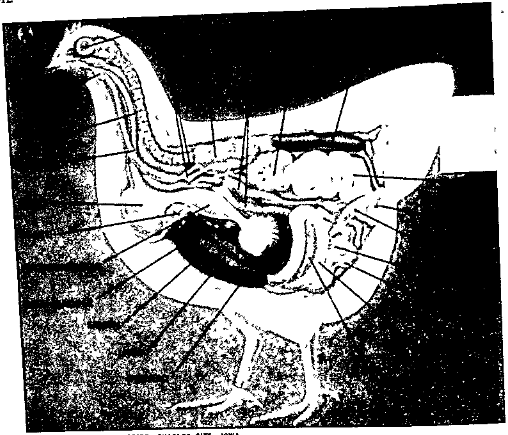
The body covering consists of the skin and its derivatives—the comb, wattles, earlobes, feathers, beak, toenails, and scales.

The skin. The skin of birds is relatively thin when compared with that of mammals. It has no sweat or sebaceous glands, except the uropygial or preen gland at the base of the tail.

The skin is a protective body covering. It consists of an outer layer, the epidermis, and an inner layer, the dermis. The feathers, beak, toenails, and scales develop from the epidermis. The comb, wattles, and earlobes develop from the dermis.

The uropygial gland produces an oily substance which the bird works into the plumage with its beak. The substance serves for weatherproofing the feathers.

A network of delicate nerves, muscles, and blood vessels courses the skin



DR. SALSBURY'S LABORATORIES, CHARLES CITY, IOWA

Fig. 3–1. Sectional diagram of the chicken.

and extends to the feather roots. The skin of a fowl is very sensitive when a bird is molting.

The color of the skin, beak, and shanks is determined by the presence of skin pigments. For instance, yellow shanks are due to the presence of lipochrome pigment in the epidermis, with the absence of melanin pigment. Black and its variations depend upon the presence of melanin pigment. When a bird is in production, the yellow bleaches out of the skin, eye rings, earlobes, beak, and shanks. The practical use of pigmentation for estimating the past laying performance of hens is discussed on page 85.

When a bird is growing or in production, the skin is soft and waxy. When a bird is out of production or in poor health, the skin is hard and dry.

Feathers. A bird is known by its plumage. Feather patterns and colors are made use of in identifying breeds and varieties of chickens (Fig. 2–2).

Feathers help protect the body from physical injury and aid in keeping it warm. Wing feathers are essential for flight. In most species of birds, including the fowl, the feathers are arranged in rows in definite areas or feather tracts. The ten major feather tracts of the chicken, listed in the usual order of feather development, are shoulder, thigh, rump, breast, neck, abdomen, leg, back, wing, and head.

There are three principal kinds of feathers, based on structure: contour, plumule, and filoplume. *Contour feathers* cover the body. They vary greatly in size and shape, depending on the sex of the chicken and location of the feathers on the body. Contour feathers so completely cover the body that they conceal possible body defects. It is therefore essential to handle the birds in order to determine their true body shapes. *Plumules* or small downy feathers cover chicks and are found on adult birds beneath the contour feathers. They possess a soft shaft and a vane without barbs. They retain body heat well. *Filoplumes* are hairlike degenerated feathers, remaining after a bird has been plucked. They are particularly abundant in the region of the head and neck.

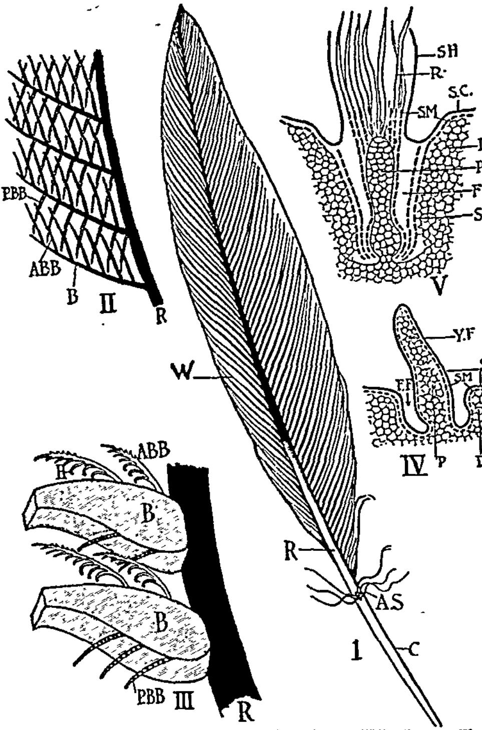
A typical feather consists of eight parts: the quill, shaft, accessory plume, fluff or undercolor, web or surface colors, barbs, barbules, and barbicels (Fig. 3–2). The *quill* is cylindrical and hollow and makes up the base of the feather. Nutritive material for feather growth enters through the quill, giving it a pink to black appearance. In mature feathers the quill is filled with a gray pulp. The *shaft* or rachis is the continuation of the quill or stem up through the center of the feather. The *accessory plume* is a small rudimentary feather or down growing on the under side of the feather at the base of the shaft. It appears only on mature feathers and hence serves a useful purpose in distinguishing old feathers from the new. The *fluff* or undercolor is the downy portion of the feather, not visible when feathers are in normal position. The *web* or surface color is the flat visible portion of the feather. The *barbs* are projections extending from both sides of the shaft. The *barbules* are small processes projecting from either side of the barbs. The barbules from one side of a barb fit into notches of the barbules projecting from the adjacent side of the next barb. The *barbicels* or cilia are outgrowths from the sides of the barbules. Some of them bear microscopic hooklets which are linked to the barbules next in front. The barbules and barbicels hold the barbs together and add strength to the feather.

In the newly formed bird, the first indication of feathers is the formation of tiny papillae or buds on the delicate skin of the embryo (about the sixth day in the chick). The skin immediately around the papilla sinks downward, so that later the papilla is enclosed in a follicle of the skin.

The outer layer of the epidermis forms for the developing feather a protective sheath, which is cast off as the feather is formed. The elements of the tip and border of the feather are first laid down and then the shaft and the quill.

A second generation of feathers (at time of molt) is formed from the persisting follicles. A feather bud starts to grow at the base of the old feather, causing it to loosen and finally fall out. In the general body plumage a feather is not often regenerated more than three times. The precise pattern of the feather is usually reproduced each time.

Coloration of plumage is produced by pigments, by physical structure, or by combinations of them. Physical or structural coloration is illustrated by color changes with changing light and position of the eye. The pigments are chiefly lipochromes and melanins.



FROM "THE BIOLOGY OF BIRDS" BY J. A. THOMPSON BY PERMISSION OF THE MACMILLAN CO., PUBLISHERS

Fig. 3–2. Structure and development of the feather (diagrammatic). I. A typical feather: C, calamus or quill; A.S., after-shaft, R, rachis; W, web vane and barbs. II. An enlarged part of vane: R, rachis; B, barb; A BB, anterior barbule; P.BB, posterior barbule. III. Two barbs enlarged. IV. An early stage in feather development: Y.F, young feather; P, the internal pulp or dermis; F F, the feather follicle; D, the dermis. V. A later stage in feather development: R, barbs; SH, sheath; D, dermis; P, pulp; and F, follicle.

Feathers are composed chiefly of proteins. They constitute from 4 to 9 per cent of the empty live weight, depending on the age and sex of the individual. An adequate supply of good quality protein in the ration is essential for normal feather growth. Fairly high humidity and a moderate temperature are also conducive to good feather growth. Activity of the endocrine glands influences feather development. For example, castrated males (capons) grow longer neck, saddle, and tail feathers than do cockerels (Fig. 3–14).

Feather shapes and colors are helpful in the determination of sex and age of birds. For example, the saddle feathers of males are long and pointed, while the corresponding cushion feathers of females are short and rounded. This characteristic difference is helpful in separating the sexes of general-purpose breeds of broilers. The large feathers of the wings and tail are definite in number and are generally molted and replaced in regular order. This fact is made use of in culling and selecting birds for egg production (Chapter 4).

The Skeletal System

The skeleton serves as a framework for the body and the attachment of muscles, protects vital organs, holds the bone marrow, and contains air spaces which aid in flight and respiration. The bone marrow produces the red blood cells and part of the white cells.

The bird's skeleton (Fig. 3–3) differs very materially from that of the mammal. The bones are light and in some of them the bone marrow is replaced by air spaces. Many of the bones are fused together, thereby giving greater rigidity to the body. The limbs are adapted for both walking and flying. The skeleton is more compact than that of mammals and contains fewer bones.

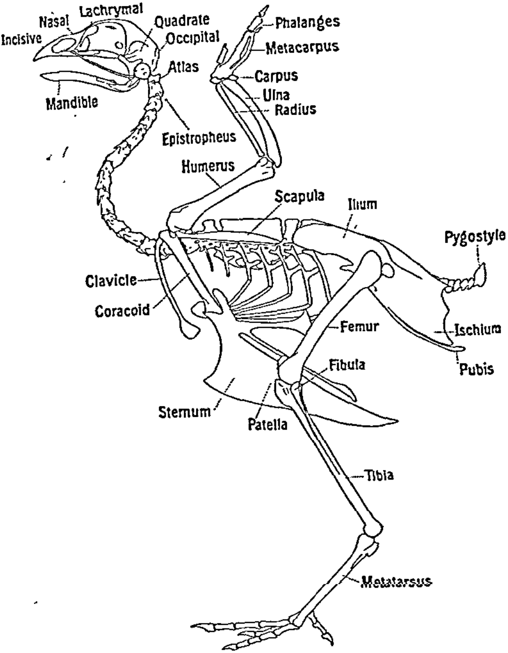
The *head* is small in comparison with other body parts. The jaws are known as mandibles and form the bird's beak. The nasal cavities open into the roof of the mouth from a point just back of the upper mandible. The orbit cavities are large. The brain is well encased in the rounded and fused cranial bones.

The *neck* is long and very flexible. The cervical vertebrae fit upon each other in such a way that there is great freedom of movement of the head and neck for eating, care of plumage, defense, and other purposes.

The *backbone* shows much fusion of vertebrae. It ends in a rudimentary tail, the pygostyle. The pygostyle supports the main tail feathers.

The *wings* correspond to the arms and hands of man. The large humerus bone connects with the interclavicular air sac (Fig. 3–6). There are three fingers but only one of them is well developed. The wing is carried folded on the back.

The *hind limbs* are adapted for walking and perching. The thigh is concealed beneath the feathers. The tibia or "drumstick" is the largest bone of the limb. Most breeds of chickens have four toes, three extending forward



FROM "THE STRUCTURE OF THE FOWL," BY O. C. BRADLEY

Fig. 3-3. The skeleton of a fowl.

and one backward, although Dorkings and Houdans have five toes. The toes end in claws, which aid in scratching and perching. The spur above the toes is more developed in males than females and is used for defense. The older the bird, the greater the spur development.

The *ribs* are attached above to the spinal column and below to the sternum. They are braced to each other by bones to give a firmer framework.

The *sternum* or breastbone is very large and projects back beyond the ribs,

forming a part of the abdominal floor. The sternum protects the vital organs above it. A thin blade, the keel, projects downward from the sternum. The flight muscles are attached to it.

The *pectoral girdle,* corresponding to the shoulder girdle in mammals, consists of the scapulae or shoulder blades, the coracoids, and the clavicle or "wishbone."

The *pelvic girdle* is not a closed system of bones as in mammals. It makes reproduction or egg laying less difficult. The pelvic girdle consists of the ilia, ischia, and pubes or "lay bones" in the hen. The pubes have a tendency to straighten out when a bird is in production and to curve in when the bird is out of production. There is a tendency for the rear of the keel to drop down when a bird is in production and to be drawn up toward the pubes when the bird is out of production.

Bone tissue is first laid down as cartilage. This is followed by ossification or the deposit of inorganic salts, chiefly calcium phosphate. The dry matter of bone consists of about 75 per cent organic matter and 25 per cent inorganic matter. During the growth of long bones, such as those of the legs and sternum, unossified growth zones are left near the ends. They finally ossify. The rear of the sternum, for instance, does not harden and may be bent until the bird is nearly a year old. An examination of the sternum may be used to differentiate between pullets and hens.

A deficiency of vitamin D or minerals results in poor calcification and weak spongy bones of low ash content. This nutritional disease of the bones is known as rickets. An excessive amount of phosphorus or a deficiency of manganese in the ration results in enlarged hock joints and crooked legs among broilers. This bone disease is known as perosis. These and other nutritional diseases are discussed in Chapter Nine.

The Muscular System

The muscles produce body movements, generate body heat, cover the bones, and fill out the body contour. The muscles of the wings, legs, abdomen, and other parts of the body work in pairs. While one of the pair contracts to cause movement the other one relaxes. Muscle work requires food for energy and produces body heat.

The *pectoral* muscles, the largest in the body, raise and lower the wings. They are attached to the sternum and keel of the fowl and constitute the "breast" of the bird. Muscles which open and close the wing are attached to the humerus.

The *pectineus muscle* (m. ambiens) found in the hind limb of the fowl does not have a counterpart in mammals. It enables the bird to maintain itself upon a perch even while asleep. When the hind limb is bent, a slender tendon which crosses obliquely the front of the knee joint exerts a pull on the flexor muscle that bends the toe automatically round the perch. When resting, the mere weight of the body bends the hind limbs and consequently causes the toes to grasp the perch and hold the bird firmly in place.

The *diaphragm* of the fowl is rudimentary and does not form a partition

between the thoracic and abdominal cavities as in mammals. The muscle is represented by a tendinous membrane, lying on the ventral surface of the lungs.

The *dermal* muscles extending to the base of feathers make feather movement possible.

Muscles are supplied by nerves and blood vessels. Oxidations in muscles with resulting heat and energy production are determined by the blood circulation. Both the blood vessels and muscles are controlled by nerves. When nerves are destroyed, or paralyzed by toxins, there is a loss of muscular activity and the bird becomes paralyzed. Abnormal muscle development or control is responsible for such body defects as wry tail and split wing.

Myoglobin pigment, found in thigh muscles but not in breast muscles, accounts for the difference in dark and light meat.

The Digestive System

The digestive system consists of the alimentary tract and its accessory organs—the liver, pancreas, and spleen. It differs very materially from that of mammals.

The digestive system serves for food intake, storage, digestion, and elimination of body waste products.

The alimentary tract. The alimentary tract (Fig. 3–4) consists of the mouth, gullet, crop, glandular stomach, gizzard, small intestine, ceca, large intestine, cloaca, and anus.

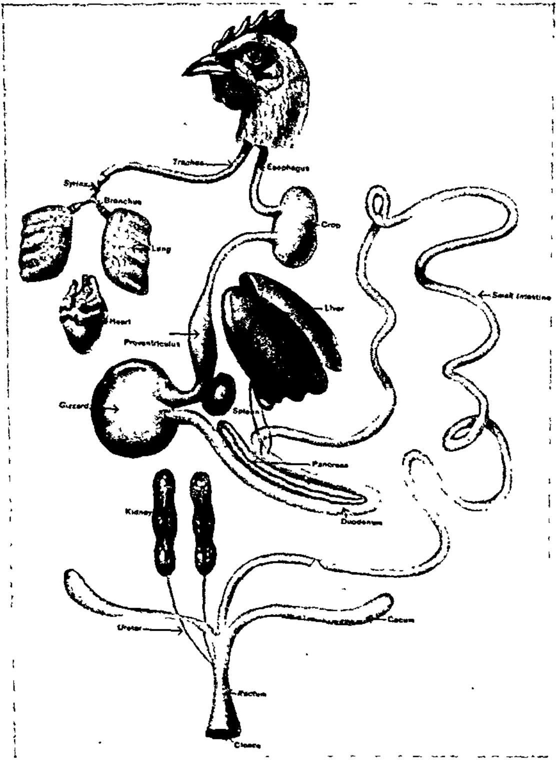
The *mouth* is characterized by the absence of lips, cheeks, and teeth. The chicken is provided with a beak which is used in tearing apart and picking up its food. The pointed tongue is provided with barbed-like projections which serve the purpose of forcing the food back to the gullet. A small cup-like projection is made in the tongue for holding water when drinking. The bird must raise its head when swallowing or the water will run out through the nostrils, which open into the roof of the mouth. Numerous mucous glands in the mouth provide saliva for moistening the food for ease in swallowing.

The *gullet* is the tube leading from the back part of the floor of the mouth (pharynx) to the glandular stomach. It is characterized by its great expansibility.

The *crop* is the enlargement of the gullet just before it enters the body cavity. It serves for the temporary storage of food. Here the food is softened by saliva that was swallowed with the food, and by secretions from the crop wall.

The *glandular stomach* (proventriculus) is the thickened portion of the tube connecting the gullet and the gizzard As the food passes from the crop to the gizzard, the glandular cells of the proventriculus secrete a pepsin-hydrochloric acid mixture into the canal which passes with the food to the gizzard.

The *gizzard* or muscular stomach joins the glandular stomach and the duodenal loop of the small intestine. Its walls consist of large, red, thick powerful



COURTESY MERCK AND CO., RAHWAY, N. J.

Fig. 3–4. The intestinal tract and other internal structures of the fowl.

muscles and its lining is a thick horny epithelium. The gizzard crushes food particles and mixes them with the pepsin-hydrochloric acid solution. Proteins are partly digested and minerals are dissolved in the gizzard.

The *small intestine* extends from the gizzard to the large intestine. It con-

between the thoracic and abdominal cavities as in mammals. The muscle is represented by a tendinous membrane, lying on the ventral surface of the lungs.

The *dermal* muscles extending to the base of feathers make feather movement possible.

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The digestive system serves for food intake, storage, digestion, and elimination of body waste products.

The alimentary tract. The alimentary tract (Fig. 3–4) consists of the mouth, gullet, crop, glandular stomach, gizzard, small intestine, ceca, large intestine, cloaca, and anus.

The *mouth* is characterized by the absence of lips, cheeks, and teeth. The chicken is provided with a beak which is used in tearing apart and picking up its food. The pointed tongue is provided with barbed-like projections which serve the purpose of forcing the food back to the gullet. A small cuplike projection is made in the tongue for holding water when drinking. The bird must raise its head when swallowing or the water will run out through the nostrils, which open into the roof of the mouth. Numerous mucous glands in the mouth provide saliva for moistening the food for ease in swallowing.

The *gullet* is the tube leading from the back part of the floor of the mouth (pharynx) to the glandular stomach. It is characterized by its great expansibility.

The *crop* is the enlargement of the gullet just before it enters the body cavity. It serves for the temporary storage of food. Here the food is softened by saliva that was swallowed with the food, and by secretions from the crop wall.

The *glandular stomach* (proventriculus) is the thickened portion of the tube connecting the gullet and the gizzard. As the food passes from the crop to the gizzard, the glandular cells of the proventriculus secrete a pepsin-hydrochloric acid mixture into the canal which passes with the food to the gizzard.

The *gizzard* or muscular stomach joins the glandular stomach and the duodenal loop of the small intestine. Its walls consist of large, red, thick powerful

spaces in the bones. The lungs are inexpansible. The active part of breathing is expiration rather than inspiration.

The respiratory system supplies oxygen for body oxidation, removes carbon dioxide, eliminates water from the body, and aids in the control of body temperature.

The respiratory system (Fig. 3–5) consists of the external and internal nares, glottis, larynx, trachea, syrinx, bronchi, lungs, and air sacs.

The *external nares,* or openings just back of the upper mandible, open into the cleft in the roof of the mouth.

The *glottis* is the back part of the floor of the mouth. Air is drawn through the nasal cavities into the glottis, where it passes on through an opening into the trachea.

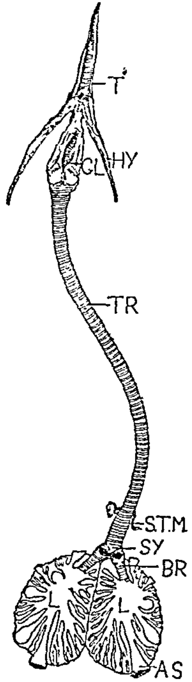
The *larynx* is the slitlike opening, surrounded by a ring of cartilage, in the floor of the glottis. It is attached to the upper end of the trachea. The larynx is kept closed when swallowing food and water. It may become clogged with phlegm when a bird has bronchitis, and cause death by strangulation.

The *trachea* or windpipe is the tube leading from the larynx to the syrinx or voice box. It is a long tube surrounded by rings of cartilage.

The *syrinx* or voice box is the constricted portion of the air passage at the lower end of the trachea. It is a flexible valve which is vibrated when air is forcibly expelled from the lungs, thus producing sounds. A number of muscles make it possible to alter the tension of this valve and consequently the number of its vibrations and the pitch of the note produced.

The *branchi* are the two branches leading from the syrinx to the lungs.

The *lungs* consist of pinkish spongy masses of tissue imbedded in the dorsal thoracic wall on both sides of the spinal column. The lungs are coursed by many branches of the bronchi, which lead into minute canals beset with thin membranous pouches. There is a rich vascular circulation in the membranes of the walls of the lungs. Oxygen passes from the lungs into the blood and



FROM THE BIOLOGY OF BIRDS BY J. A. THOMPSON BY PERMISSION OF THE MACMILLAN CO PUBLISHERS

Fig. 3–5. Trachea and lungs of the fowl: T, tongue; HY, horns of hyoid; GL, glottis; TR, trachea or windpipe; S.T.M., *sternotracheal* muscles; SY, syrinx or voice box; BR, bronchal tubes; L, cavity of lungs; A.S, mesobronchus leading into the abdominal air sac.

sists of the duodenal loop and coils of the free portion. The coils are held by a thin membrane, the mesentery. The small intestine of the average hen is about sixty-two inches in length.

Digestive juices are secreted into the duodenal loop from the pancreas for digestion of carbohydrates, proteins and fats. Alkaline bile is secreted into this region from the gall bladder to neutralize the acids and create a favorable alkaline condition for the action of the digestive enzymes. Digestion is completed in the small intestine. (See Chapter 8 for digestion details.) Absorption of digested food into the blood stream takes place in the coiled portion of the small intestine.

The *ceca* are two blind pouches extending forward from their point of origin at the juncture of the small and large intestine. They are about seven inches long and are usually filled with soft, pasty undigested food (fecal material). The function of the ceca is unknown. They may be removed without impairing the health of the bird.

The *large intestine* extends from the small intestine to the cloaca. It has about twice the diameter of the small intestine and is about four or five inches long. The large intestine holds the fecal matter until it is excreted into the cloaca.

The *cloaca* is the enlarged portion of the alimentary canal connecting the large intestine and the anus or vent. Fecal material from the large intestine, eggs from the oviduct, and urine from the kidneys all pass into the cloaca and are then eliminated by way of the vent.

The *anus* or vent is the external opening from the cloaca.

The accessory organs. The *liver* consists of two large brown lobes of tissue lying by the gizzard and duodenal loop. It produces a greenish alkaline fluid, the bile, which is stored in the gall bladder, a thin, dark-green sack located under the right lobe of the liver. The liver serves as a purification plant for digested food before it enters the general circulation, stores glycogen or animal starch, and transforms protein waste products into uric acid and other products suitable for elimination by the kidneys.

The *pancreas* is a narrow strip of pinkish tissue lying between the folds of the duodenal loop. It secretes the enzymes—amylase, trypsin, and lipase—into the duodenal loop for the digestion of carbohydrates, proteins, and fats. The pancreas also secretes a hormone, insulin, which regulates sugar metabolism.

The *spleen* is generally regarded as one of the accessory organs of the digestive system. It is a reddish-brown body shaped like a buckeye. The spleen lies in a triangle formed by the liver, gizzard, and glandular stomach. The function of the spleen is not definitely known. It removes broken-down red blood cells and is capable of storing iron and blood.

The Respiratory System

The respiratory system of the chicken is quite different from that of mammals. The lungs connect with air sacs which in turn connect with hollow

spaces in the bones. The lungs are inexpansible. The active part of breathing is expiration rather than inspiration.

The respiratory system supplies oxygen for body oxidation, removes carbon dioxide, eliminates water from the body, and aids in the control of body temperature.

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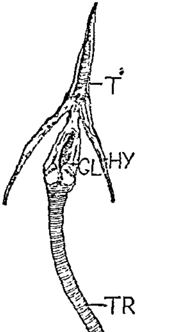

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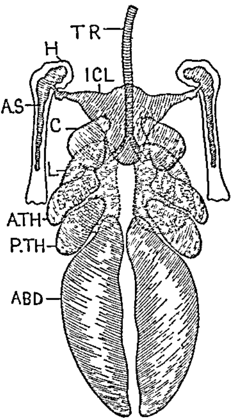

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Fig. 3–6. The system of air sacs in a bird: L, the right lung; C, a cervical air sac; ICL, the interclavicular air sac; A.S, an outgrowth into the humerus bone; A.TH, anterior thoracic air sac; P.TH, the posterior thoracic; ABD, the abdominal air sac; TR, the trachea.

carbon dioxide passes from the blood to the lungs.

The *air sacs* are accessory lungs. There are four pairs and a large single air sac in the fowl (Fig. 3–6). They connect the lungs with the hollow spaces in the bones of the limbs and other parts of the skeleton. The air sacs serve for respiration, impart lightness and buoyancy to the body, and permit diffusion of water from the blood to be excreted from the lungs in the form of vapors. It is estimated that one hundred hens secrete about a gallon of water daily by way of the lungs.

The *interclavicular* air sac connects the hollow spaces in the bones of the wings with the anterior ends of the lungs. The large abdominal air sacs occupy the spaces between the abdominal organs and the body walls. They connect the hollow spaces of the leg bones with the lungs. The *anterior* and *posterior thoracic* air sacs lie in the chest cavity. They connect with the lungs only. The *cervical* air sacs lie close to the interclavicular air sac, and connect the cervical and thoracic vertebrae with the lungs. Birds have been found injured by shot, which were breathing through a splintered wing bone when the trachea was clogged with blood excluding the passage of air.

In respiration, as the abdominal muscles relax and the rear of the sternum drops down, air is drawn in through the lungs and into the abdominal air sacs. As the abdominal muscles contract and the rear of the keel is drawn up, air is forced out of the abdominal air sacs and on out through the lungs. The average respiration rate of the hen is 36 per minute and that of the male 20 per minute.

The Circulatory Systems

The circulatory systems consist of the blood and lymph circulations. The blood circulation is in a closed system under pressure (90 to 180 mm.) while the lymph circulation is a more open system with little or no pressure. The blood circulation serves for the transfer of digested food, waste products, oxygen, carbon dioxide, water, and hormones to and from the body cells. It

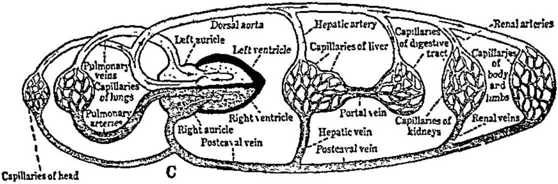

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Fig. 3–7. A diagram of the blood-circulating system of the fowl and mammal. The heavier shading represents unoxygenated blood; arrows indicate the direction of flow.

also aids in the regulation of body temperature, the control of body neutrality, and protection against disease. The lymph circulation bathes the cells, serves as a medium of transfer of food and waste products between the blood capillaries and body cells, and carries fats.

The blood circulatory system. The blood circulatory system consists of the heart, arteries, capillaries, veins, and blood (Fig. 3–7).

The *heart* is the pump for the blood circulation. It consists of two entirely separated muscular ventricles and two thin-walled auricles. The heart receives the impure blood through veins leading from the head and body regions. The blood is pumped through the lung circulation where it gives off carbon dioxide and takes in oxygen. The blood returns to the heart and is pumped out through the aortic arch and its arterial branches to all parts of the body. The heart beat or pulse rate ranges from about 192 to 396 per minute, with an average of about 282.

The *arteries* carry blood away from the heart. Pulmonary arteries carry blood to the lungs. The carotid arteries supply blood to the head; the brachial arteries supply the wings; and the dorsal aorta gives off branches which supply the liver, digestive tract, kidneys, and legs. Arterial blood is a brighter red than venous blood because of its increased oxygen content. Arterial blood is also under greater pressure than venous blood. The average pressure in the femoral artery is 135 mm.

The *capillaries* are very small blood vessels which connect arteries and veins.

The *veins* carry blood to the heart. They are usually located close to the corresponding arteries and generally bear the same names. For instance, there is a brachial artery and brachial vein in the wing. Blood is returned to the heart from the head regions through the jugular and precaval veins and from the body regions through the postcaval vein. When birds are killed and bled for market, the jugular vein is severed at the point of union of the two branches at the base of the head (Fig. 11–10). The knife blade is directed against the neck wall. Blood samples are taken for the pullorum agglutination test by puncturing a branch of the brachial vein. In caponizing birds one must

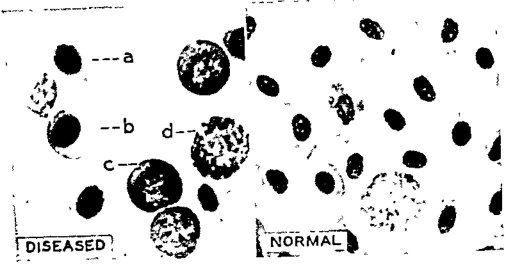

Fig. 3–8. Blood cells from a normal and leucemic fowl: a, erythrocyte; b, erythroblast; c, lymphocyte; d. polymorphonuclear leucocyte. Magnified 1350 X. (Illinois Station Circular 467.)

use extreme care to avoid puncture of the postcaval vein. It passes along very close to the testes.

The blood. The blood is the mixture of liquid and cells flowing in the blood circulatory system. The liquid part of the blood is called *plasma.* It carries digested food in solution to the cells, waste products from the cells, solutions of salts for maintaining body neutrality, hormones, and the blood cells.

There are two principal kinds of cells floating in the blood, the red cells or *erythrocytes* and the white cells or *leucocytes* (Fig. 3–8). The erythrocytes are small and oval in shape with large nuclei. They carry oxygen from the lungs to the body cells and carbon dioxide from the body cells to the lungs. The oxygen and carbon dioxide are carried in the red cells in loose chemical combination with an iron-containing protein, hemoglobin. The leucocytes are larger and fewer in number than the red cells. They may be subdivided into several different groups. The leucocytes help to protect the body against disease; in case of an infection the leucocyte count in the blood increases.

The blood constitutes about 4 per cent of the empty live weight of the fowl. It consists of about 75 per cent water and 25 per cent solids. The blood contains from 2,000,000 to 4,000,000 red cells and 15,000 to 35,000 white cells per cubic milliliter. The plasma contains a substance, fibrinogen, which is essential for blood clotting. The blood of the fowl clots quickly. The liquid which separates from the clot is known as *serum.* It is used in making the tube agglutination test for pullorum disease (p. 322).

The lymph circulatory system. The lymph circulatory system consists of the lymph vessels, the white cell-forming organs, and the lymph. The lymph capillaries collect the lymph fluid and pour it into the lymph veins, and these in turn, carry it to the large veins adjacent to the heart. The lymph

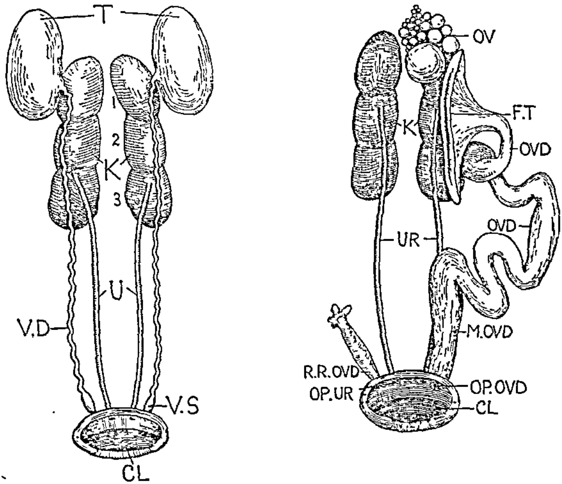

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Fig. 3–9. The urinary and reproductive systems of the fowl: male, left; and female, right. T, testes; K—1, 2, and 3, lobes of the kidneys; V.D, vas deferens; U, ureters; V.S, seminal vesicle; CL, cloaca; OV, ovary; F.T, funnel of oviduct; OVD, oviduct; M.OVD, uterus of the oviduct; UR, ureters R.R.OVD, rudimentary right oviduct; OP.UR, opening of the right ureter; OP.OVD, opening of the oviduct; CL, cloaca.

vessels in birds are numerous. The lymph glands are few. They may be seen in the anterior breast and the neck region, and sometimes in the wings.

The Urinary System

The urinary system is located close to the reproductive system, as in mammals. It serves for the elimination of body waste products which are chiefly protein in nature. The chicken does not have a urinary bladder. It excretes very little liquid urine.

The urinary system consists of the kidneys and ureters (Fig. 3–9). The *kidneys* are large three-lobed, soft, brown organs attached to the vertebral column just back of the lungs. Many small blood vessels course the kidneys. Protein waste products and water (forming the urine) filter through the walls of the blood vessels into the collecting tubules of the kidneys. The *ureters* are the urinary tubes leading from the kidneys to the cloaca. A single tube leads from each kidney.

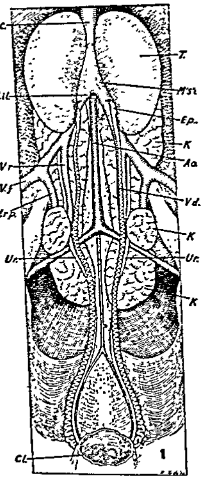

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Fig 3–10. The male reproductive and urinary systems: T., testis; V.d., vas deferens; K, kidney; Ur., ureter; Cl., cloaca; H, head of reproductive cell or sperm; T, tail of sperm

The urine passed from the kidneys to the ureters daily by the normal-sized fowl amounts to 700 to 800 cc. As it passes along through the ureters, in the region of the large intestine, much of the water is reabsorbed into the body circulation. The urine passes from the ureters into the cloaca and becomes mixed with the fecal material deposited from the large intestine. The urine and fecal material are eliminated together from the cloaca. The urine, which is chiefly uric acid, is the white pasty material seen on the droppings.

The Reproductive System

The male reproductive system. The male reproductive system produces male reproductive cells (spermatozoa), introduces them into the oviduct of the female for fertilization of the egg, and produces a hormone which influences sex characters.

The male reproductive system consists of the testes, vas deferens, and papillae or rudimentary copulatory organs (Fig. 3–10). The *testes* are two small ovoid organs situated at the anterior end of the kidneys in the dorsal body wall. Some of the cells produced in the testes differentiate into gametes or reproductive cells. They enter the seminiferous tubules and are carried out of the testes by the seminal fluid, which is also produced in the testes. The spermatozoon is a long, slender, motile cell with a head, which contains the nucleus, a neck, and a tail. Millions of these cells are produced and expelled in the seminal fluid. The *vas deferens* are the two tubes pursuing a wavy course from the testes to the cloaca. They convey the spermatozoa and seminal fluid from the testes to the cloaca. The *papillae* or rudimentary copulatory organs are located in the cloacal wall. The vas deferens open on the summit of the papillae During the process of mating, the spermatozoa are introduced by the papillae into the oviduct opening in the cloacal wall of the female.

The testes are sometimes removed from cockerels if they are to be raised

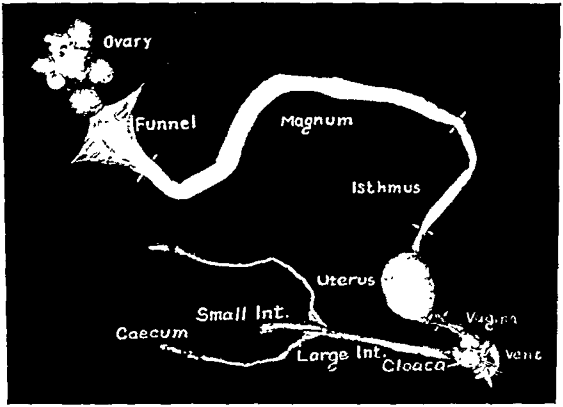

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Fig. 3–11. The female reproductive system and a portion of the intestinal tract.

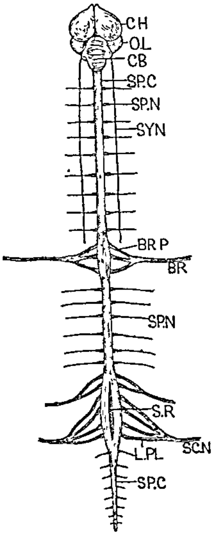
to maturity for meat. This process is known as caponizing. Capon meat is more tender and of better quality than that from old cockerels. Caponized birds lose some of their sex characteristics.

The female reproductive system. The female reproductive system differs greatly from that of mammals. The reproductive cell, also known as a gamete, ovum, or egg, is an article of food. It is large because it is enclosed with a food supply for embryo development. Most of the development of the bird embryo takes place outside of the body (Chapter 5).

The reproductive system of the female consists of the ovary and oviduct (Fig. 3–11). At hatching time the female chick has two ovaries and two oviducts. The right ovary and oviduct soon degenerate. The left ovary and oviduct develop as the bird grows. The *ovary* appears as a cluster of tiny gray yolks or ova situated at the anterior end of the left kidney and attached to the dorsal body wall. When a bird reaches sexual maturity, or comes into production, some of the ova develop to mature yolks. The yolk ruptures the membrane or follicle which holds it and falls into the funnel of the oviduct. This process is known as *ovulation*. The ovary also secretes a hormone which influences sex characteristics. The *oviduct* is a long glandular tube leading from the ovary to the cloaca. It consists of five parts: the *funnel* or infundibulum, which receives the yolk; the *magnum*, which secretes the thick albumen or white; the *isthmus*, which adds the shell membranes; the *uterus*, which secretes the thin white, the shell, and the shell pigment; and the *vagina*. Details of the formation of the egg are given on pages 63–65. The egg

passes from the oviduct to the cloaca and then out of the body through the vent at the time of laying.

Abnormal conditions of the reproductive system are very common. The ovary may contain abnormally shaped and colored ova as a result of pullorum infection or tumors. The oviduct is easily ruptured and may pass out with the egg or permit eggs to fall into the body cavity.



FROM "THE BIOLOGY OF BIRDS" BY J. A. THOMPSON. BY PERMISSION OF THE MACMILLAN CO., PUBLISHERS

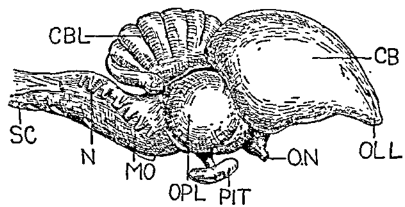
Fig. 3–12. The nervous system of the fowl: C.H, cerebral hemispheres of the brain; O L, optic lobes; CB, cerebellum, SP.C, spinal cord; SP.N, spinal nerves; SY.N, sympathetic nervous system; BR.P, brachial plexus to wing; S.R, rhomboidal sinus; L.PL, lumbar plexus of nerves uniting to form the sciatic nerve (SC.N).

The Nervous System

The fowl has a highly developed nervous system with a keen sense of sight, hearing, touch, taste, and smell. The nervous system is often called the master tissue of the body because it controls body activities. It receives messages from the outer world through its sense organs, adjusts the body to its environment by controlled movements, and harmonizes the vital activities.

The nervous system (Fig. 3–12) consists of the brain, spinal cord, branches leading to the sense organs, and sympathetic nerves, which control the viscera. It may be compared to a telephone system with the sense organs of sight, hearing, touch, taste, and smell as telephones; the nerve fibers as wires; and the brain as the switchboard.

The central nervous system. The *brain* (Fig. 3–13) consists of three principal parts: the cerebral hemispheres, the cerebellum, and the medulla oblongata. The two *cerebral hemispheres* constitute the front and most conspicuous part of the brain. The olfactory nerves from the nose extend to the cerebral hemispheres. The elongated oval *cerebellum* lies upon the medulla oblongata and extends forward to the cerebral hemispheres. The *medulla oblongata* is the back part of the brain which is continuous with the spinal cord. Most of the cranial nerves take origin from it. The medulla oblongata is severed or crushed in debraining birds for dry picking. This releases the muscular tension on the feathers.



FROM "THE BIOLOGY OF THE FOWL" BY J. A. THOMPSON. BY PERMISSION OF THE MACMILLAN CO., PUBLISHERS

Fig. 3–13. A sideview of the brain of the fowl: CB, cerebrum; OL.L, olfactory lobe; O.N, optic nerve; PIT, pituitary body; OP.L, optic lobe; MO, medulla oblongata; N, nerve issuing from spinal cord (SC); CBL, cerebellum.

The *spinal cord* is the main trunk line of the nervous system, extending from the brain to the body trunk. It sends out branches to the wings, legs, and peripheral nerves of the skin, and connects with the sympathetic nerves, which control the viscera.

Vitamin deficiency results in nerve degeneration and certain forms of paralysis. In neurolymphomatosis the nerves may be swollen and have a yellowish color instead of the characteristic gray appearance. Poisons or toxins result in nerve paralysis and a lack of muscle control. This is the cause of "limberneck" in chickens.

The sense organs. The *eye* of the bird is relatively large and lodged in a bony orbit. It is used for transforming light waves in visual perception. The optic nerve leads from the brain to the eye. The details of the structure of the eye and nerve action in visual perception are beyond the scope of this book. It is interesting to note that the eye has a third eyelid in the form of a thin membrane, the *nictitating membrane,* which can be drawn quickly over the eye. It operates somewhat like the lens shutter of a camera. When not in use, the membrane is mainly concealed within the medial angle of the eye. The normal color of the eye in most breeds of chickens is a reddish-bay. In some forms of the disease known as leucosis, the color becomes pearl-gray. Toxins resulting from tapeworm infestation and other troubles may cause blindness.

The *ear* of a bird does not form any external appendage to the head as in mammals. An opening surrounded by a fringe of feathers leads into a canal which ends at the tympanic membrane. The inner ear contains the essential parts of the organ of hearing. It is imbedded in the temporal bone. The ear system serves for the transformation of sound waves into nerve impulses and for maintaining body equilibrium. The auditory nerve leads from the brain to the ear.

The *nose* serves not only for respiration but also for the sense of smell. Olfactory nerves lead from the brain to the membranes in the walls of the nasal passages.

The Regulatory System

The regulatory system is composed of endocrine glands. The glands secrete substances, known as hormones, into the blood stream. These chemical sub-

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Fig. 3–14. A Plymouth Rock cockerel on the right and a capon on the left.

stances are carried to other organs of the body and exert a profound influence on their activities.

The *testes* secrete a hormone which is responsible for the marked difference between males and capons. When a cockerel is caponized, the comb and wattles fail to develop normally and the hackle, saddle, and tail feathers grow longer than in normal males (Fig. 3–14). If a normal testis is grafted into a capon it recovers its normal male characteristics. The same effects are produced by the injection of the male hormone extract or one of the synthetic products, such as testosterone. Male sex hormone products are assayed for strength by testing their ability to produce comb growth in capons. The male sex hormone is responsible for a higher red blood cell count in males than females. It may also be responsible for the higher metabolism in males than females.

The *ovary* produces a hormone which helps to differentiate the two sexes. The female hormone exerts an inhibitory effect on the development of the secondary sex characteristics. If the ovary is completely removed from a female, the bird has a tendency to develop male plumage and sex characteristics. The injection of female hormone extract into males causes them to take on the plumage color characteristic of the female rather than that of the male.

Diethylstilbestrol and other derivatives of stilbene are synthetic hormones which produce effects somewhat similar to the female hormone estrogen.

When injected into growing cockerels or old males, they cause the birds to quit crowing and begin singing; the pelvic bones to spread; the vent to become moist; the lipoid content of the blood to increase; and fat to collect under the skin and in the abdomen. The males appear and act something like pullets that are about to begin egg production. Synthetic female hormone injection, pellet implant beneath the skin, and addition to the feed have been advocated for fattening poultry (p. 176) and for stopping broodiness among layers.

Tumor growths and other abnormalities may impair the testes or ovary to such an extent that the bird gradually loses its normal sex characteristics and assumes more of the characteristics of the opposite sex.

The *adrenals* are small oval or elongated yellowish bodies located on the dorsal body wall just in front of the kidneys. One of the adrenal hormones is adrenalin, which influences carbohydrate metabolism and regulates blood pressure. The adrenal glands are also believed to influence sex-gland activity.

The *pancreas* functions as an endocrine gland as well as an accessory organ of the digestive system. In man it secrets a hormone, insulin, which regulates sugar metabolism. The pancreas probably also regulates sugar metabolism in the bird.

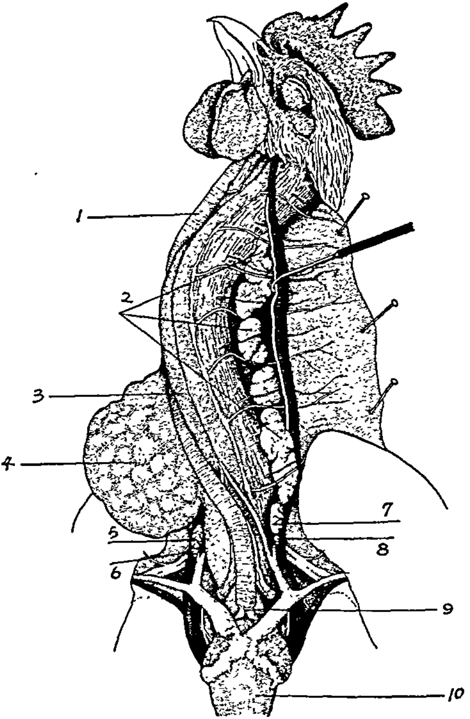
The *thyroids* are two small oval brown bodies a little larger than a grain of wheat located close to the jugular veins near the base of the neck Fig. 3–15). They secrete a hormone known as thyroxin, which influences feather growth and coloration as well as the rate of body metabolism.

Thyroprotein, also known as iodinated casein or protamone, is an artificial thyroxin-like compound, which produces some of the accelerated metabolic effects of thyroxin. There is some evidence that its use in the ration at the rate of about 10 grams per 100 pounds of feed will stimulate egg production of old hens and produce faster and more uniform growth of broilers. Thiouracil produces the opposite effect of thyroprotein. It blocks the action of the thyroid gland; reduces the metabolic rate; and causes fat deposition. While early feeding of thiouracil stunts growth, its use later in the growing period has increased body weight and improved market appearance of broilers and roasters.

The *parathyroids* are small glandular bodies located close to the thyroids. They secrete a hormone which regulates calcium and phosphorus metabolism. Parathyroid secretion is an important factor for laying hens because of the large amount of calcium needed for eggshell formation. Birds in production need to carry much more calcium in the blood stream than those out of production.

The paired *thymus* glands occur as thin pinkish lobes along the neck. They are large in chicks but diminish in size with the age of birds. The function of the thymus is unknown. It may play a part in growth.

The *pituitary* or hypophysis is a small kidney-shaped gland located at the base of the brain. It is composed of different kinds of tissue, each secreting a specific hormone substance. One product stimulates both male and female gonad activity. Artificial lights increase egg production by stimulating the



COURTESY J. F. NONIDEZ AND H. D. GOODALE

Fig. 3-15. Structures of the neck region of the fowl: 1, trachea; 2, thymus; 3, gullet; 4, crop; 5 and 7, thyroids; 6 and 8, parathyroids; 9, syrinx or voice box; 10, heart.

pituitary gland which in turns secretes a substance that stimulates the ovary to produce eggs. Use of lights on birds which have had the anterior lobe of the pituitary removed does not result in ovarian activity.

Another pituitary hormone, prolactin, activates the crop glands of pigeons and thereby produces "pigeon milk." It induces milk production in mammals but inhibits ovarian development and causes broodiness in the fowl.

The *pineal body* is a small round gland just back of the cerebral hemispheres of the brain. It probably secretes a hormone but its function is unknown.

Formation and Structure of the Egg

A knowledge of the formation and structure of the egg is helpful for an understanding of fertility, embryo development, egg quality, and diseases of the female reproductive system.

Yolk development. The ovarian tissue appears as a cluster of tiny ova or yolks. Other ova, too small to be seen with the unaided eye, are more deeply imbedded in the ovarian tissue. One may count from a few hundred to more than 3,000 ova in an ovary without the aid of a magnifying glass. When the ovary starts to function, a few of the ova start to increase in size (Fig. 3–11 and 16). The ovum is enclosed in a thin membrane, the *vitelline membrane.* The yolk and its vitelline membrane are in turn enclosed in a highly vascular coat of connective tissue, the *follicle.* As the ovum or yolk increases in size it is suspended in its follicle and held to the ovary by a slender stalk, the *follicle stalk.*

Food material is carried to the developing ovum by the blood circulation in the follicle. The developing yolks increase about four mm. in diameter daily until the full size of about forty mm. is reached. The *nucleus* of the ovum moves to the outer edge, leaving behind it a flask-shaped mass of white yolk (Fig. 3–17). Alternate layers of *dark and white yolk* may be deposited during the period of rapid yolk development. The size of yolks influences the size of the finished eggs. Large yolks stimulate the albumen and shell glands to greater secretion.

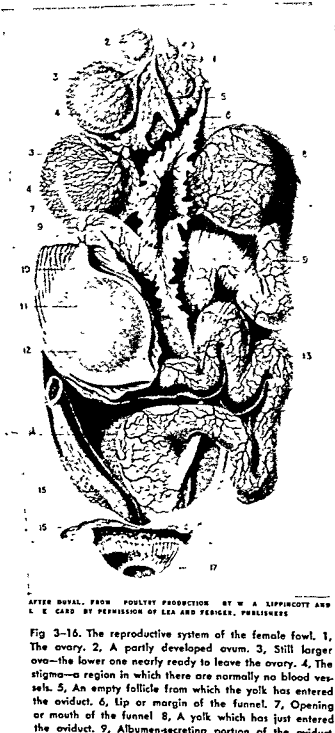
Ovulation. When the yolk has reached maturity, the follicle ruptures along a definite line, the *stigma,* where there are normally no blood vessels. The yolk falls into the funnel of the oviduct or into the body cavity. This process is known as *ovulation.* Yolks which drop into the body cavity, a cup-like depression formed in the angle between the ovary, folds of small intestine, and oviduct, are normally pushed or drawn into the funnel of the oviduct by the movements of the viscera and oviduct. If the yolks fail to get back into the oviduct the bird is known as an internal layer. The yolks may rupture and the liquid be reabsorbed into the circulation, leaving an abnormal deposit of yellow solids covering the intestine, or the yolks may dry up, leaving masses of caked egg-yolk material in the body cavity.

Fertilization. If the hen has been mated and male sperm cells are present in the oviduct, fertilization takes place in the funnel region. The yolk re-

mains in this region for a few minutes. Details of fertilization and the transmission of hereditary characters are discussed in Chapter 4.

Embryo development in the body. The fertilized ovum starts cell division and embryo development soon after fertilization. It continues during the approximate twenty-four hours that the egg remains in the oviduct. The germ spot or blastoderm increases in size and there is some change in the consistency of the white and yolk. Unless the fertile egg is held below 82° F. after it is laid, there will be further germ development. It is therefore desirable to produce infertile eggs at all times except when they are needed for hatching. The details of embryo development are discussed in Chapter 5.

Addition of the thick white and chalaza. After the yolk has been engulfed by the funnel of the oviduct, it moves along with a turning motion through the magnum. It requires about three hours for the yolk to pass through this region. Here the thick white and the dense ropy material known as the chalaza (Fig. 3–17) are added. The thick white



AFTER DUVAL, FROM POULTRY PRODUCTION BY W. A. LIPPINCOTT AND L. E. CARD BY PERMISSION OF LEA AND FEBIGER, PUBLISHERS

Fig 3–16. The reproductive system of the female fowl. 1, The ovary. 2, A partly developed ovum. 3, Still larger ova—the lower one nearly ready to leave the ovary. 4, The stigma—a region in which there are normally no blood vessels. 5, An empty follicle from which the yolk has entered the oviduct. 6, Lip or margin of the funnel. 7, Opening or mouth of the funnel 8, A yolk which has just entered the oviduct. 9, Albumen-secreting portion of the oviduct. 10, Albumen which is secreted around the yolk. 11, Yolk. 12, The germinal disc. 13, Anterior end of the isthmus, in which the shell membranes are formed. 14, The uterus, or shell gland 15, The large intestine. 16, The abdominal wall, cut and laid back 17, Anus or vent.

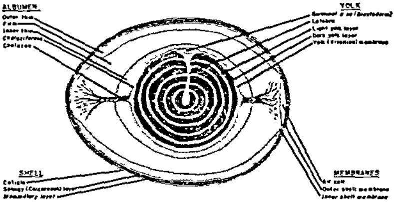


Fig. 3–17. Structure of the egg.

has a tendency to adhere to the yolk when an egg is broken out. It constitutes about 50 per cent of the total white by volume.

Formation of the shell , membranes. The yolk, surrounded with its thick white, passes from the magnum through a short section of the oviduct known as the isthmus. Here the two shell membranes are added and the shape of the egg is determined. An isthmus of large diameter tends to result in thick round eggs while one of small diameter tends to result in long slender eggs.

Addition of thin white and the shell. The developing egg passes from the isthmus into the uterus, where it remains for about twenty hours. The thin white, largely water, passes through the shell membranes into the egg in the first portion of the uterus. Even before the addition of the thin white has been completed, the shell glands of the uterus start the secretion of the shell. This is largely calcium carbonate. It is carried to the uterus by the blood circulation. The size of the oviduct in a laying hen and its blood circulation are several times greater than that of a hen out of production.

The pigment in brown-shelled eggs is secreted in the uterus. The cuticle or bloom, a moist substance noticed covering the newly laid egg, is also secreted in the uterus. Soon after the egg is laid the substance dries and tends to seal the openings in the porous shell.

After the egg reaches the hard-shell stage in the uterus, it is possible to detect it by pressing on the walls of the abdomen. By handling all the birds early in the morning, one can determine the hens that will lay during the day.

The egg remains in the vagina for a short time after completion or until it is laid. Most eggs are laid small end first. They pass from the vagina into the cloaca and are expelled at once.

Abnormal eggs. *Double-yolked* eggs result from two ova ripening at the same time, or one ovum being pushed back into the oviduct at the same time that another ovulation takes place. Eggs with double yolks are more common among pullets than among older birds. It takes time for the newly functioning ovary and oviduct to become properly adjusted and to work normally.

Meat spots may be observed on the yolk covering or in the white of the egg. They are generally degenerated blood clots resulting from hemorrhages in the ovary or oviduct.

Blood spots may be found in some eggs. They result from the hemorrhage of a small blood vessel in the ovary or oviduct. A blood or meat spot on the yolk indicates a hemorrhage in the ovary or funnel region of the oviduct.

The follicle probably did not rupture along the stigma, where there are normally no blood vessels, or else a rupture occurred before ovulation (Fig. 3-16). If the spot is in the white of the egg, it indicates a hemorrhage in the wall of the oviduct. Bloody eggs are probably the result of more severe hemorrhages. The reproductive system of the female may be easily ruptured when in production. Selection of hatching eggs from families that produce eggs with a low incidence of blood spots will do much to correct this egg abnormality.

Soft-shelled eggs may result from failure of the shell glands to secrete; or they may result from the peristaltic constrictions becoming so violent as to hurry the egg through the uterus. Most shell-less eggs are probably laid at night. This would indicate that certain ways in which birds roost may cause abnormal pressure on nerves leading to the oviduct.

Small yolkless eggs may result from the stimulus produced by some foreign substance, such as a blood clot or piece of membrane, gaining entrance to the oviduct and passing along in the same manner as the yolk. The passage of the particle will stimulate the albumen, shell membrane, and shell glands to secrete their particular products.

An egg within an egg is sometimes found. After an egg has been formed it may be forced back up into the funnel region by reverse peristaltic action. As it again traverses the oviduct, albumen, shell membranes and shell are added. When the egg is opened a complete egg is found where the yolk is normally present.

If the reverse peristaltic action is very strong, the egg may be forced entirely out of the oviduct into the body cavity. An accumulation of eggs in the body cavity causes a bird to walk like a penguin and will finally result in death.

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Chapter 4

Breeding Principles and Practices

Heredity

HEREDITY ACCOUNTS FOR the fact that offspring tend to resemble their parents. Not only do the offspring hatched from a single-comb White Leghorn mating resemble birds and chickens, but also the specific single-comb White Leghorns. A chicken is composed of many characters. Its *physical characters*, such as size, shape, type of comb, and color of plumage, are easily seen. Its *physiological characters*, such as rate of growth, early maturity, and egg production, cannot be seen by looking at the individual. The parents transmit both physical and physiological characters to their offspring through their *gametes* (reproduction cells). The science which deals with heredity and the origin of individuals is *genetics*.

The Genetic Basis of Reproduction

The cell. The component substance of living things is *protoplasm*. In higher forms of plant and animal life it is organized into small, usually microscopic units called *cells*. The higher forms of living things consist of millions of cells, which vary greatly in shape, size, and composition, depending on the functions to be performed. For instance, cells range all the way from bacterial cells so small that it is impossible to see them even when magnified 1,000 times, to nerve cells more than a foot long and ostrich eggs weighing 45 ounces.

The cell is a complicated structure (Fig. 4–1). The *cell wall* is the boundary of the cell separating it from other cells. The light staining area within the cell wall is the *cytoplasm*. It contains many interesting structures, but most of them are of more interest to cytologists than to poultrymen. The dark staining area in the cytoplasm is the *nucleus*. It varys greatly in size, shape, and structure in different cells The nuclei of reproductive cells are vital for the transmission of hereditary characters.

Continuity of germ plasm. The gametes and the cells which give rise to them constitute the *germ plasm*. The cells which take no direct part in the production of gametes are known as *somatic cells*. While the somatic cells cease to exist with the death of the individual whose body they constitute, the germ plasm may live on indefinitely in succeeding generations.

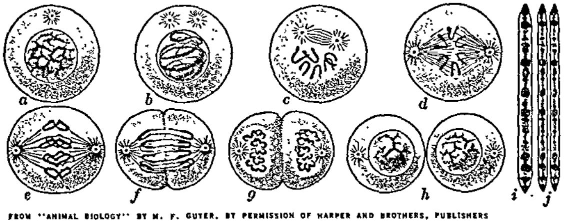

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Fig. 4-1. Diagram of the cell and mitosis: a and h, resting cells; b—g, stages in cell division; i and j., the halving of each chromosome.

In the higher vertebrates, including the fowl, the germ plasm of a single individual cannot survive by itself; there must be successful union of the male and female gametes. The two cells pass on all the hereditary characters of the parents to the new offspring.

The quality of the germ plasm of any one individual is only half of the story; of equal importance is that from the opposite sex. If either gamete brings defective germ plasm, the body and the germ plasm of the offspring will suffer accordingly.

Early history of the gametes. Even before *it is possible to tell whether the new individual will be a male or female, certain large cells in the embryo differentiate from their neighbors to become the primordial sex cells. They differentiate in the walls of the yolk sac and migrate to the developing gonads* (reproductive organs). Sexual differentiation of the embryo becomes observable shortly after the germ cells become established in the gonads.

Development of male gametes. Part of the germ line, which migrated to the walls of the seminiferous tubules of the male gonads, becomes active when a cockerel reaches sexual maturity. These parent cells grow and divide (undergo mitosis) to form new cells. Part of the new cells remain like the parent cells and take the place of others which grow, undergo maturation division (Fig. 4–2), and differentiate into slender mature *spermatozoa* (male gametes).

The nuclear material collects in the head of the male gamete. The flagella-like tail makes its appearance *in the protoplasm and grows far beyond the original confines of the cell. Thus, a mature male gamete is a cell consisting* essentially of a very compact nucleus provided with a flagellum which gives it the power of locomotion in a fluid medium.

Development of female gametes. In the growing ovary of the embryo, the female germ cells grow and divide much the same as the male germ cells grow and divide in the testes. In the mature pullet the development of ova (female gametes) is different from the development of spermatozoa in the mature male because of the amount of food stored as yolk in the cells. The food material, destined to be used by the embryo in its growth, is gradually

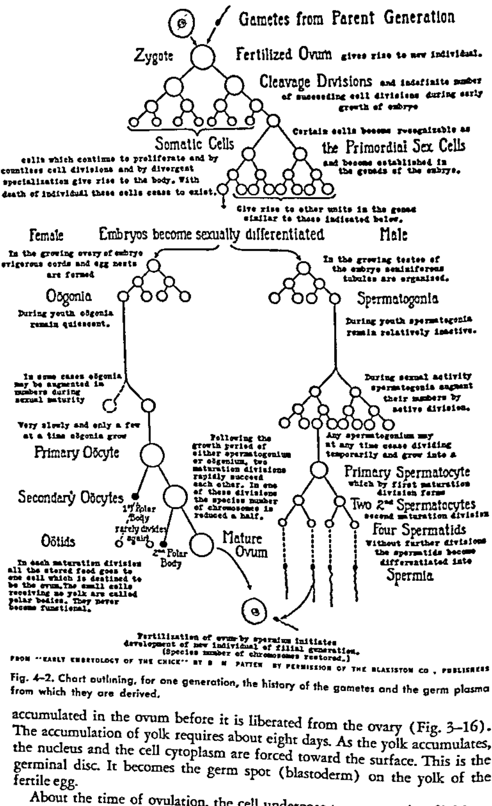

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Fig. 4–2. Chart outlining, for one generation, the history of the gametes and the germ plasma from which they are derived.

accumulated in the ovum before it is liberated from the ovary (Fig. 3–16). The accumulation of yolk requires about eight days. As the yolk accumulates, the nucleus and the cell cytoplasm are forced toward the surface. This is the germinal disc. It becomes the germ spot (blastoderm) on the yolk of the fertile egg.

About the time of ovulation, the cell undergoes two maturation divisions.

The yolk material does not divide. Therefore, one of the new cells has all the yolk and the other has none. The one without yolk degenerates.

Fig. 4-3. The chromosomes of the fowl. (After Hance.)

Significance of chromosomes in heredity. When a resting cell (Fig. 4-1a) starts to grow and divide, the dark-staining chromatin particles in the nucleus arrange themselves in one or more long, deeply stained threads (Fig. 4-1b). The threads shorten and may be observed as pairs of dark-staining segments of different shapes and sizes (4-1c). These segments are the *chromosomes*. The number and shape of chromosomes are constant for a given species of animal. According to Newcomer (1957), there are six pairs in the chicken which are relatively large and behave as normal chromosomes. There are several smaller ones that are irregular in their behavior, variable in number, and probably have little influence on an individual's inheritance.

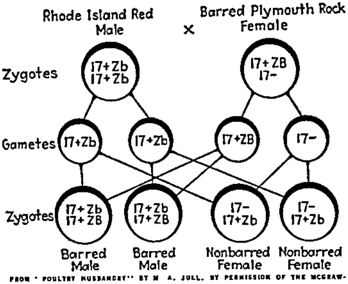
The chromosomes arrange themselves about the equatorial plate between the two poles of the cell (Fig. 4-1d). Next in the stage of development, are double threads which appeared originally to be a single thread (Fig. 4-1e).

To form gametes the reproductive cell now undergoes two cell divisions without an increase in the number of chromosomes, half of the original number going into each new cell. This is sometimes referred to as maturation or reduction division. The distribution of the chromosomes in the new cells is a matter of chance. Thus, in the words of Patten,

> In the game of life, the maturation processes virtually shuffle the hereditary pack and deal out half a hand to each gamete. A full hand is obtained by drawing a partner from the "board"—by combining with some other gamete of the opposite sex. Hence, offspring resemble their parents because they play the game of life with the same kind of cards, but not, however, with the same hands. The minor differences in offspring, or the variations from the standard type that always go with these basic resemblances, are due to variations in the distribution of genes during maturation.

There are several sources of evidence which indicate that the hereditary characters are carried by the chromosomes: (1) The male and female gametes are the only things directly involved in the formation of a new individual. (2) The nuclei of the male and female gametes are the only parts of the gametes that are directly concerned with fertilization, and the start of a new individual. (3) The chromosomes are the only things that are alike in the male and female gamete nuclei, and it is known that both parents contribute equally to the characters of the offspring.

Fertilization. The sperm ducts in the testes produce spermatozoa. They combine with a secretion in the vas deferens to form semen. It is deposited in the oviduct at time of mating. The spermatozoa are very motile and work their way through the lower part of the oviduct. They are stored in the



FROM "POULTRY HUSBANDRY" BY M. A. JULL, BY PERMISSION OF THE MCGRAW-HILL BOOK CO., PUBLISHERS

Fig. 4-4. A diagram illustrating the inheritance of sex and the sex-linked character for barring. The Rhode Island Red male has 2 sex chromosomes, designated Z, associated with each of which is the gene b for non-barring. The Barred Plymouth Rock female has only one sex chromosome Z, associated with which is the sex-linked gene B for barring, which is dominant to non-barring. The male progeny are barred, whereas the female progeny are non-barred.

pockets at the anterior end of the oviduct. The sperm are not all released at one time. Passing ova will be fertilized over a period as long as 30 days from one insemination.

Once the swarm of spermatozoa reach the neighborhood of the ovum, they tend to remain there, held by some chemical interaction which is not fully understood. A cone of ovum cytoplasm rises up to meet one of the sperm cells and draws it into the ovum. Once a sperm has penetrated the ovum, the surface covering appears to undergo a chemical change and thickening which keeps out other sperm cells.

The tail of the sperm cell drops off when it enters the ovum. There are now two nuclei in the ovum, one carrying the haploid number of chromosomes from the female parent, and the other nuclei from the male. The fertilized egg now carries the same number of chromosomes (eleven or twelve, according to Newcomer) as a cell from one or the other of its parents. The fertilized ovum is known as a *zygote.* It is now ready to undergo cell growth, mitosis, differentiation, and development into a new individual. For details of embryo development, refer to Chapter 5.

The Inheritance of Sex

Sex chromosomes. The chromosomes are of two kinds: those dealing with sex are known as sex chromosomes, and all the others are autosomes. The nucleus from the female parent may have five or six large chromosomes, but the male always contributes six to each of his offspring. A zygote giving rise to a male contains a pair of sex chromosomes, having received one from the nucleus of the gamete from each parent (Fig. 4-4). A zygote giving rise to a female has only one sex chromosome, having received it from the nucleus of the gamete from the male parent. When large numbers of fertilizations are considered, one should expect as many males as females among the offspring.

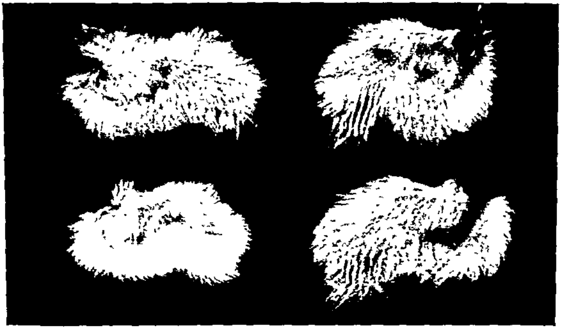


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Fig. 4–5. Flight feather development in day-old male and female chicks from crossing a White Leghorn male with a Rhode Island Red female. Note the well-developed flight feathers of the female (right) and the very short flight feathers of the male (left).

Sex-linked inheritance. *An individual's inheritance is equal to the total* of its genes. Since there are more characters that make up a bird than there are chromosomes in each of its cells, each chromosome must carry more than one character. The unit for a character is known as a *gene*. One might compare each chromosome to a string of beads and each bead on the string to a gene. The characters (genes) carried on the sex chromosomes are known as sex-linked characters.

Sex-linked characters are transmitted from the dam to her sons but not to her daughters, although these same characters are transmitted from the sire to his sons and daughters alike. The results of mating a Barred Plymouth Rock hen and a Rhode Island Red male may be used to illustrate sex linkage. The male offspring from such a mating are barred and the females are black. When the Barred Plymouth Rock *female's gametes containing* the sex chromosomes unite with those from the male's, which also contain the sex chromosomes, zygotes result which contain two sex chromosomes. These unions result in males with barring. The female's gametes without the sex chromosomes, upon uniting with the male gametes, result in zygotes with only one sex chromosome. These unions result in black females. Barring is therefore a sex-linked gene. Two sex *chromosomes in an individual result in a male* and one sex chromosome results in a female. Other sex-linked characters of practical importance are broodiness, slow feathering, and early maturity.

Sex-linked matings for the determination of sex at hatching time. The knowledge of *sex linkage* can be used *in mating* birds so that the sex of the chicks can be determined at hatching time by the down patterns. If Barred Plymouth Rock females are mated with Buff Plymouth Rock or Rhode

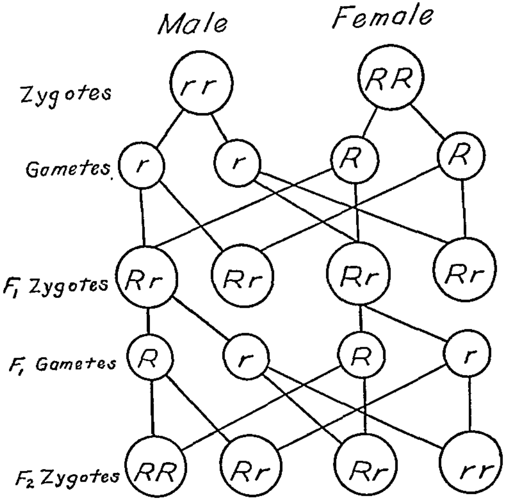

Fig. 4–6. Inheritance of a pair of characters. When a rose-comb (R) female is crossed with a single-comb (r) male, the first generation birds have rose comb (dominant character). When the F_1 birds are mated among themselves, about 75 per cent of the F_2 generation will have rose combs and the remainder will have single combs.

Island Red males, the male offspring will be black on top of the body with a white spot on the head and yellow shanks and beak. The females will be solid black on top of the body with dark shanks and beak.

If males of the Mediterranean class are mated with slow feathering females of the American, English, and Asiatic classes, the female day-old chicks will have well-developed wing feathers (Fig. 4–5). The males will have very short or no primary wing feathers.

The sexes of Barred Plymouth Rock chicks can be determined with 90 to 95 per cent accuracy by the shape of the down color on the top of the head and by shank color. The cockerel head spot is irregular in outline and scattered in appearance. The color of the shank is lighter than that of the female and blends with that of the foot. The pullet head spot is more regular in outline and does not exhibit the scattered appearance present in the cockerel head spot. The pullet shank is usually black or dark amber in color.

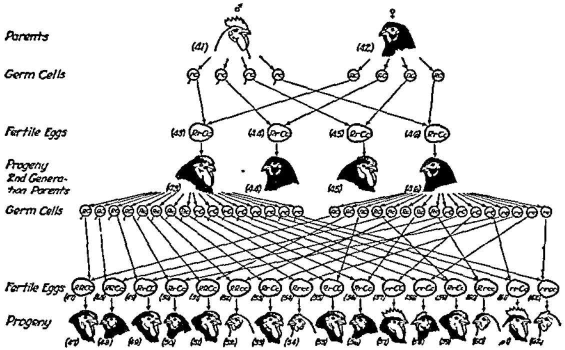

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Fig. 4–7. Diagram showing the transmission of two independent simple characters from generation to generation.

The dark color in the typical female chick terminates abruptly at the base of the shank or a short distance out on the toes and the remainder is lighter in color.

The Inheritance of Characters

Mendelism. The discovery of the law governing the inheritance of a pair of characters was made by Gregor Mendel and published in 1865. Mendelism simply means the biological theory of heredity first formulated by Mendel. He worked with hereditary characters in garden peas, but the principles he discovered are of universal application to both plants and animals.

The inheritance of a pair of characters. The mating of a White Wyandotte hen and a White Plymouth Rock male may be taken as an example (Fig. 4–6). Wyandottes have rose combs, and Plymouth Rocks have single combs. One may designate the gene for rose comb by R and that for single comb by r. The gametes from the pure Wyandotte will carry only factor R for rose comb and those from the Plymouth Rock will carry only factor r for single comb (Fig. 4–6). When the birds are mated, the offspring, or F_1 generation, will all have rose combs. The character (rose comb) is called dominant while the (single comb) that does not appear is termed recessive.

Half of the gametes from the F_1 generation will carry the factor R and the others will carry r. If birds of the F_1 generation are mated among themselves, part of their offspring will have rose combs and part will have single combs. The ratio, subject to sampling error, will be three rose combs for each

single comb. If an R gamete from one sex unites with an R gamete from the other sex, the resulting zygote will carry the factor RR which is pure for rose comb. If an R gamete of one sex unites with an r gamete from the opposite sex, the resulting zygote will carry the factor Rr. Since R is dominant to r, the offspring will have rose comb, but it will be impure. If an r gamete from one sex unites with an r gamete from the opposite sex, the resulting zygote will carry the factor rr, which is pure for single comb. The birds RR and rr are *homozygous;* that is, they are pure for the comb character. The birds Rr are *heterozygous;* that is, they are impure for either comb character. The ratio of rose-comb birds to single-comb birds in the F_2 generation is three to one. This is the *phenotypic* ratio. The ratio with reference to purity for comb character is 1:2:1. This is the *genotypic* ratio.

Inheritance of two pairs of characters. The crossing of a Black Wyandotte with a White Plymouth Rock may be used to illustrate the inheritance of two pairs of characters.

It is customary to designate dominant characters by capital letters and

Table 4–1

INFLUENCE OF THE NUMBER OF CHARACTERS INVOLVED ON THE NUMBER OF F^2 INDIVIDUALS NECESSARY THAT ONE MAY BE HOMOZYGOUS FOR ALL OF THEM

Number of Pairs of Characters	Number of Different F_1 Gametes Formed	Number of F_2 Individuals Required to Secure One Homozygous for All the Characters
1	2	4
2	4	16
3	8	64
4	16	256

recessive characters by small letters. Rose comb (R) is dominant to single comb (r), and black (B) is dominant to white (b). The F_1 generation produces four possible combinations of genes in the gametes (Fig. 4–7) instead of only two, as in the inheritance of one pair of characters. Since four kinds of gametes are produced by each sex, the possibilities for the segregation and recombination of the characters is four times as great as in the case when only two kinds of gametes are formed. The F_2 zygotic ratios then become 9 rose-comb black, 3 rose-comb white, 3 single-comb, and 1 single-comb white, or 9:3:3:1. If comb alone is considered, there are 12 rose combs and 4 single combs, a 3:1 ratio. If color alone is considered, there are 12 blacks and 4 whites, or a 3:1 ratio. These ratios are what would be expected when two pairs of characters are inherited independently of each other. Of the sixteen zygotes formed, one is homozygous for rose comb and black color, and one is homozygous for both single comb and white color. These zygotes are different from those of the original parents and of the F_1 generation and could have been produced only through the random assortment of the chromosomes.

Most of the other zygotes are genetically different from those of the original parents.

The inheritance of several pairs of characters. When more than two pairs of characters are involved and the different genes producing the characters are on different chromosomes, the segregation and assortment of characters behave in the same way as the inheritance of one or two pairs of characters. The number of different kinds of gametes formed by the F_1 generation is doubled with each additional character involved. On the other hand, for each additional character involved there is an increase of four times the number of F_2 individuals required to secure the expected appearance of the various combinations of characters resulting from the chance combination of the different kinds of F_1 gametes. (Table 4–1.)

Dominant and recessive characters. Some of the characters whose inheritance has been determined are listed in Table 4–2. Most of them are simple characters. Some are more complicated than they appear in the table.

Table 4–2

SOME DOMINANT AND RECESSIVE CHARACTERS IN CHICKENS

Character	Dominant or Recessive	Sex-Linked
White plumage	In White Leghorns, dominant to color In Wyandottes, recessive to color	
Black plumage	Dominant to recessive white	
Buff plumage	Dominant to recessive white	
Barred plumage	In Plymouth Rocks, dominant to nonbarring	Yes
White skin and shank color	Dominant to yellow skin and shank color	
Rose comb	Dominant to single comb	
Side sprigs	Dominant to normal comb	
Feathered shanks	Dominant to nonfeathered shanks	
Close feathering	Dominant to loose feathering	
Slow feathering	Dominant to rapid feathering	Yes
Early sexual maturity	Dominant to late sexual maturity	Yes
Broodiness	Dominant to nonbroodiness	Yes
Winter pause	Dominant to continuous laying	

White in the White Leghorn, for instance, is dominant to colored plumage. If a White Leghorn is mated to a colored bird, the F_1 generation will all be white but some of the birds may have some colored feathers. The dominance of white in the Leghorn is due to the presence of a gene which inhibits color; otherwise the bird would be barred, for it carries genes for barring, color, and black pigment. Some strains of White Plymouth Rocks are also dominant.

It is interesting to note that white is not always dominant. It depends on the breed. While white is dominant to color in the Leghorn, it may be recessive to color in the Wyandotte.

The inheritance of about fifty characters has been determined to date.

With some characters the determination of their Mendelian inheritance is slow because many genes are involved. Furthermore, the expression of characters may be influenced by environment, hormones, feeding, and management practices. For instance, a bird may have inherited the genes for high egg production but may not lay well because it is fed a poor ration.

Testing for purity of characters. An impure recessive character may be carried in a flock for generations without being detected, if matings are made with birds which are pure for the dominant gene. The impurity may crop out unexpectedly when two impure individuals are mated.

Some White Wyandotte flocks produce a few single-comb chicks. This indicates a single-comb impurity in the flock, as Wyandottes have rose combs. Since rose comb is dominant to single comb, the birds that appear with single comb are homozygous for this character. They should be culled out. Part of the rose-comb birds in the flock will be homozygous and part will be heterozygous. To test for impurity, mate each bird with a recessive single-comb bird and hatch about six chicks. If no single-comb chicks appear in the lot, the rose-comb bird was pure for this character.

A general rule that may be applied for testing genetic constitution is to mate the bird to be tested with one that carries the pure recessive character. If none of the offspring show the recessive character, the animal was pure for the dominant character.

Blood typing is used to identify and characterize blood cell antigens. They are inherited the same as comb type or other characters. There may be a relation between blood types and economic factors such as livability, egg production, hatching potential, and growth rate. Preliminary data seem to indicate that individuals heterozygous for certain antigenic factors have superior performance in some qualities and that birds with such a constitution might have selective advantage. Time will tell whether this method offers enough promise to justify the involved serological techniques required for its utilization.

Modifications of Mendelian Inheritance

Linked genes. Some characters possessed by a bird in an original cross may be carried on into the F_2 generation. They do not follow the Mendelian laws of inheritance. The genes giving rise to these characters are said to be linked together on the same chromosome. The genes for single comb and short legs (creeper condition) exhibit linkage. The opposite to linkage is crossing over. Here there is an interchange of parts of the same pair of chromosomes. The practical significance of linkage and crossing over in poultry breeding work is yet to be demonstrated.

Lethal genes. Studies have shown that certain genes, when in homozygous condition, kill the chick embryo. An example is the cross between heterozygous creeper and normal chickens. The creeper condition is a dominant factor. The F_2 generation should give 3 creepers to 1 normal chicken. Instead, there are 2 creepers for each normal bird. The dominant homozygous individ-

ual dies in the embryonic state. Sticky embryos are recessive to normal. The "sticky" character is lethal when dominant and homozygous.

Complementary genes. The normal 9:3:3:1 ratio for the inheritance of two pairs of characters is sometimes changed by different genes producing like effects or having complementary effects.

Mutations. A new character may appear unexpectedly in one generation and be transmitted through inheritance to succeeding generations. The new character is called a "sport" or a "mutation." It is brought about by a change in a gene. The White Plymouth Rock originated as a "sport" from the barred variety.

Complex characters. Not all characters are due to single genes. For instance, laying performance is a complex character in which several genes are involved. Genetically, the number of eggs a bird will lay depends on such characters as early maturity, intensity, persistency, and nonbroodiness.

Selection of Breeding Stock

Poultry-breeding work during the period 1860–1910 was largely concerned with the development of new breeds and varieties. That the work was quite successful is evidenced by the many classes, breeds, and varieties of chickens (Chapter Two). Since about 1910, interest in poultry-breeding work has centered around the improvement of poultry for meat and egg production purposes. Birds with a first-year production of three hundred eggs are now as common as two-hundred-egg birds were thirty years ago. Yet, in the light of newer knowledge of breeding methods, it appears that poultry breeders are merely on the threshold of the possibilities that lie ahead. There is a need for a larger number of breeders more thoroughly informed concerning the fundamental factors involved in the selection of breeding stock for the development of superior strains.

Selection of males and hens for the breeding flock is more of a problem than is generally believed. Like individuals do not always beget like individuals. Physical characters, such as size, shape, and color, may be seen and judged by looking at the individual. Physiological characters, such as livability, egg production, and hatchability, cannot be seen and measured by looking at the bird.

Selection of breeding stock should be based on the laws of hereditary transmission of characters. Attempts should be made to segregate pure individuals for desirable genes, and then to assemble new stock for desirable combinations of genes by proper mating. Information regarding a bird's genetic makeup may be obtained from the individual, its ancestry, its sibs, its reproductive performance, and its progeny. The latter two are by far the most important. Much more emphasis should also be placed on the selection of males than females, because each male is mated with from ten to twenty females and produces several times as many offspring.

Selection of individuals. The first step in poultry-breeding work is the

selection of males and females to be used as breeders. The selection should be based on (1) vigor, (2) breed and varietal characteristics, and (3) production characteristics.

Vigor. Good health or vigor is the first prerequisite for a bird that is to be used in the breeding pen. It is shown by behavior and body characteristics (Fig. 4–8). The contrasts in characters, as shown by birds with good and poor vigor, are summarized in Table 4–3.

Birds with good vigor are interested in things going on around them and

Table 4–3

VIGOR CHARACTERISTICS OF BREEDING BIRDS

	Good Vigor	Poor Vigor
Character Behavior		
Activity	Very active	Inactive, tired
Attitude	Alert	Drowsy
Voice	Crow or cackle and sing	Quiet
Sex interest	Gallant or coquettish	Lack of interest
Appetite	Eat well, full crop	Eat little
Roosting	Up early, retire late	Spend much time on perches
Body Characteristics		
Shape	Parallelogram	Triangle
Back	Broad, extends well back	Narrow, wedge shaped
Keel	Long, extends well forward	Short
Breast	Full, plump	Shallow, thin
Abdomen	Deep, full	Tucked up
Size	Generally large, compact	May be small
Head	Broad, round	Long, thin, flat
Beak	Short, heavy, curved	Long, thin, flat
Comb	Large, bright red, warm	Small, pale, or purple
Eye	Large, bright, prominent	Dull, sunken
Plumage	Close, glossy	Loose, dull
Wings	Folded against body	Drooping
Tail	Upright	Drooping
Shanks	Short, thick	Long, thin

are active. They walk, run, fly, forage, scratch, sing, cackle or crow, and show sex interest. It was observed at Cornell University that a group of five males with good vigor mated 132 times with hens during twenty hours of observation, while a similar number of average vitality mated 64 times, and the group with low vitality only 39 times. Birds with low vitality have just the opposite behavior traits of those with good vitality.

Birds with good vigor have a broad, long, deep body, with a good capacity for handling feed and manufacturing eggs (Fig. 4–9). Other things being equal, birds with good, compact body size are better able to withstand long, intensive egg production than birds with small body size.

The head gives a good indication of the health of the bird. Rice has said, "The bird carries its health certificate on top of its head," meaning the comb.

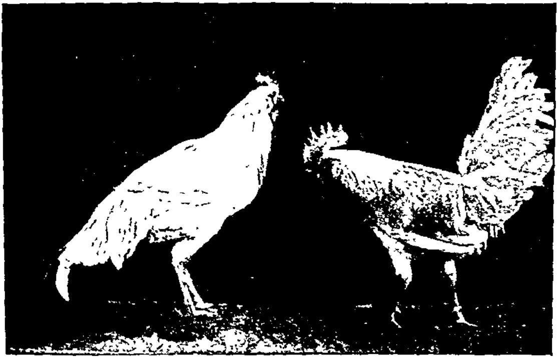

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Fig. 4–8. A Leghorn cockerel with high vitality (on the right) and one with low vitality (on the left).

A large, bright red comb indicates good vigor, while a small, pale, or dark comb indicates low vitality or a diseased condition. If the comb is large and bright red, the eyes will be bright and prominent, the face well colored, and the wattles red.

The plumage of vigorous birds is close and the feathers are "well kept," glossy, and unbroken. Vigorous birds generally molt late and quickly. Birds with poor vigor may not molt, and the plumage may be irregular and thin. *One should take past production into consideration when judging vigor by* plumage. Often birds that have been laying for a long period of time will have poorly kept plumage. They apparently are so busy producing eggs that their plumage is neglected.

Breed and variety characteristics. Individuals should be selected that are free from general disqualifications (p. 38) and that conform to the description of the breed and variety as given in the American Standard of Perfection.

While it is true that there is probably very little relation between the refinement of type and color of a bird and its production, yet one should retain the identity of the breed and variety in the flock. The buyers of poultry will usually pay more for Standard-bred stock than for birds that lack a definite breed and variety identity.

The breeding problem is simplified by choosing a variety with a solid color, such as white, in preference to one with shaded or mixed color (barring). The white color does not create a breeding problem. Barring is a problem because definite dark and light and narrow bars are preferred.

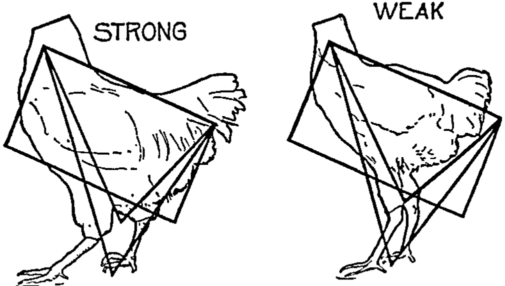

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Fig. 4–9. The way in which birds of high and low vitality fill a parallelogram and two triangles. This clearly brings out the points of weakness in development of keel, breast, and abdomen in the low-vitality bird.

COURTESY THE EARLY AND DANIEL CO

Fig. 4–10. Head of a good Barred Plymouth Rock layer (left) and poor layer (right). Note the large comb and wattles and short beak on the good layer.

Production characteristics. It is possible to secure an indication of a hen's present, past, and future egg production by physical examination of the bird. Characteristics observed and their significance are summarized in Table 4–4.

Distinguishing layers from nonlayers. In selecting good producers and culling the unprofitable birds, it is necessary to be able to distinguish hens that are laying from those that are not laying.

Table 4–4

CULLING AND SELECTION OUTLINE

Distinguishing Layers from Nonlayers

Character	Laying Hen	Nonlaying Hen
Comb	Large, red, full, glossy	Small, pale, scaly
Eye	Bright	Dull
Vent	Large, dilated, oblong, moist	Small, contracted, round, dry
Pubic bone spread	Two or more fingers	Less than two fingers
Abdomen and spread	Soft, pliable	Full, hard
	Three or more fingers between pubic bones and keel	Less than three fingers between keel and pubic bones

Estimating Past Production

	Long Laying Period	Short Laying Period
Vent	Bluish white	Flesh colored
Eye	Prominent, sparkling	Dull, sunken
Eyelids	Thin, edges white	Thick, yellow tinted
Earlobes	Enamel white [1]	Yellow tinted
Beak	Pearly white	Yellow tinted
Shanks	White, flat	Yellow, round, smooth
Plumage	Worn, soiled, close feathered	New, glossy, clean, loose feathered

Estimating Merits of Good and Inferior Layers

	Good Layer	Poor Layer
Pigmentation	Well bleached	Yellow pigment
Molt	Late, rapid, laying during molt	Early, slow
Persistency of production	Laying in August and September	Out of production in August and September

[1] Mediterranean class birds.

The color of comb and wattles gives some indication of present production. When the ovary starts to function and yolks start to develop, the comb and wattles increase in size and become bright red in color. If a bird is about ready to lay or is in production, she has a large, bright red, smooth, glossy comb, and full, smooth wattles (Fig. 4–10). Near the end of a laying period and when production stops, the comb shrinks and becomes dull, dry, and shriveled.

Condition of the vent is used to indicate production. The vent of a hen in production is large, oval or elliptical, and moist. When a bird is out of production, the vent is shrunken, puckered, and dry (Fig. 4–11).

The space between the pubic bones indicates the laying condition of a pullet or hen. As a fowl comes into laying condition, the pubic bones (Fig. 4–12) spread apart. The distance between them, when a bird is in production, will be at least one and one-half inches, even in small fowls, and may be as much as three inches in the larger breeds. A space equal to the width of one finger (about three-fourths of an inch) between the pubic bones indicates that the hen is not laying. A space greater than the width of two fingers usually shows that she is laying.

COURTESY THE EARLY AND DANIEL CO.

Fig 4–11. The influence of egg production on the condition of the abdomen and vent. Left, a bird in production. Note the large space between the pubic bones and keel, and the large, oval vent. Right, a bird out of production. Note the small space between the pubic bones and keel, and the small, flat vent.

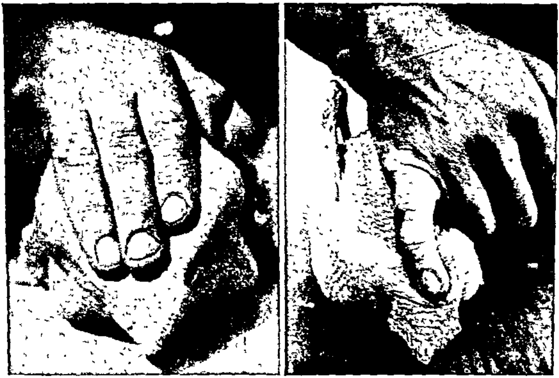
Long production causes the pubic bones to become thin and pliable. In nonlayers these bones are less flexible.

A soft, pliable abdomen indicates that a bird is in production. A full, hard abdomen indicates a nonlaying bird. A pullet or a nonlaying bird has a depth of only about two fingers between the pubic bones and the keel (Fig. 4–13). As the fowl comes into production, the abdomen expands, the keel drops down, and the space between the pubic bones and keel has a depth of three or more fingers.

Indications of good layers. The selection of hens should not be based on their present laying condition alone. The fact that a hen is laying at the time of examination is no proof that she is a good producer. Almost any hen will lay during the spring. If she is not laying in July and August of the year after she was hatched, she is likely to be a poor layer.

Although trap-nesting is the best way to ascertain the exact number of eggs a hen has laid, there are easily observed changes in physical appearance which indicate a bird's past laying performance. These include pigmentation and molt.

Pigmentation gives some information regarding a bird's past production, in case of hens having yellow skin and shanks. During the period of production, the yellow xanthophyl pigment in the feed eaten is used for coloring the yolks and the body gradually loses its reserve supply of yellow pigment.



COURTESY THE EARLY AND DANIEL CO.

Fig. 4–12. The influence of egg production on the condition of the pubic bones and abdomen. Left, a bird in production. Note the wide space between the pubic bones, and the loose abdomen. Right, a bird out of production. Note the small space between the pubic bones and the tight abdomen.

The order of disappearance of pigment from the body and the approximate period of egg production required to bleach the body structures are as follows:

Vent	1– 2 weeks
Eye rings and earlobes	2– 4 weeks
Beak	6– 8 weeks
Shanks	12–20 weeks

The pigment first leaves those structures having the best blood circulation. It leaves the beak from the base towards the tip and the front of the shanks before the back part. When a bird stops production, the pigment returns in the same order as it left and approximately twice as fast.

The rate of production and the kind of ration alter the rapidity with which pigment is lost from the body. Birds laying at a high rate lose pigment more rapidly than those laying at a low rate. Birds kept in confinement or fed very little yellow corn or alfalfa lose pigment much more rapidly than those receiving an abundance of xanthophyl pigment from green grass range, yellow corn, or alfalfa.

Molt may be used to indicate a bird's laying ability. Both the time and duration of molt should be considered.

The early molter is usually a poor layer. The normal molt occurs during the summer and fall of each laying year. Poor producers frequently stop lay-

Fig 4–13. The space between the pubic bones and the keel indicates the laying condition of a bird. Left, a bird out of production, with a narrow space between the pubic bones and keel and a hard, full abdomen. Right, a bird in production, with a wide space between the pubic bones and keel and a soft, pliable abdomen.

ing in June or July and begin to drop their feathers. They usually take a long time to complete their molt and as a rule lay no eggs during this period. They seldom start to lay before December or January. Late molters, after a rest of only a month or two, also begin to lay in December or January.

It takes about six weeks for a new feather to grow out in either a low or a high producer, but the latter grows more feathers at a time, thereby completing the molt much more quickly than a low producer. Exceptionally good hens may molt and lay at the same time.

The order of the molt is as follows: head, neck, breast, body, wings, and tail. If birds are selected in the early fall, the plumage of the good layers will show wear and tear, and is usually soiled. The early molting hens will have a growth of new feathers. The webs of the new feathers are glossy and bright in contrast to the dry, frayed webs of the old ones. The new quills are large, full of nutrients, and soft. The quills of the old feathers are small, hard, hollow, and nearly transparent. A few pinfeathers in the neck may indicate a short molting period without a stop in egg production. When the molt extends to the body and wings, the hen usually stops laying and the molt becomes complete.

It is possible to estimate when the wing molt began by counting the number of wing feathers. The primary feathers are the stiff flight feathers seen on the outer part of the wing when it is spread out (Fig. 4–14). They are separated from the secondary feathers by a short feather (axial feather). There are

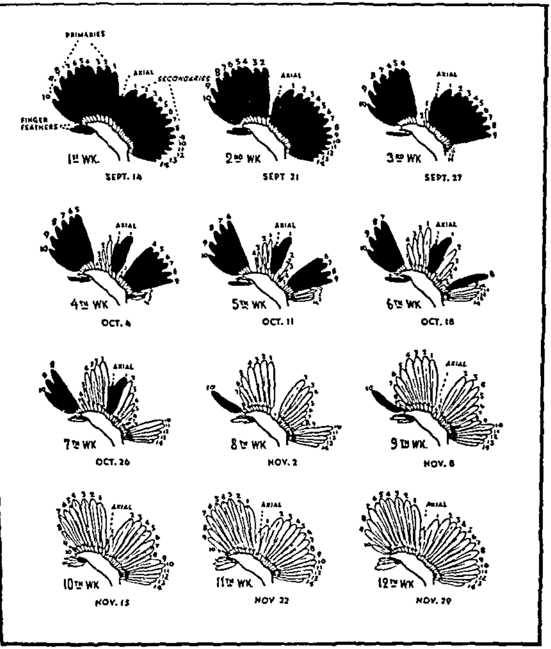


Fig. 4–14. A diagram showing weekly stages of the wing molt. The black portions represent the old feathers, while the new ones are represented by the feather outlines. (Cornell Bulletin 503.)

usually ten primary feathers on each wing, and they are molted from the axial feather toward the tip of the wing. Early and slow molters generally drop one or two primary feathers at a time. Late and fast-molting birds shed three or more primary feathers at a time. *Since it takes about six weeks to grow a new wing feather, and two-thirds of the growth is made during the first three weeks, one can estimate the time of wing molt by observing the number and length of the new primary wing feathers.* The new feathers will be clean and bright with a soft quill and broad outline. The old primaries are much more faded, soiled, worn, and pointed.

The trap-nest record. The trap-nest record gives the true picture of a bird's egg-laying performance. It not only gives the number of eggs laid, but is necessary for a study of egg characters and individual reproductive performance.

Ancestry. A good individual with good ancestry is to be preferred to one with poor ancestry because it is more likely to carry the genes for the desired character. It should be remembered that good ancestry only betters the chances; it does not guarantee purity. The greater the variation in the environmental conditions, the ration, and management practices, the less the reliance that can be placed upon the ancestors' records of production in the selection of progeny for future breeding purposes.

Sibs. The records of the brothers and sisters in a family furnish further evidence of an individual's desirability as a breeder. The probability is greater that the bird under consideration is pure for the genes for the characters he carries when his brothers and sisters have the characters.

Reproductive performance. A bird will be of little value as a breeder unless it reproduces well. It may lay many eggs but still be of little value as a breeder if it has few or no progeny.

Fertility of eggs is the first limiting factor determining the number of offspring. Low fertility may result from sterility or partial sterility of the male, barrenness of the female, aversion or favoritism on the part of the male, or a lack of sex interest in either sex. Fertility is an individual characteristic which is not readily inherited by offspring. It remains more or less constant from year to year. There appears to be no relation between fertility and hatchability.

Hatchability is an inherited character. A hen may lay a large number of fertile eggs, yet many of the embryos will die in the shell. The poor hatchability may be due to lethal genes. Some of these are stickiness, deformed mandibles, and malpositions of embryos.

Livability of chicks hatched is the final measure of a bird's reproductive performance. Chicks from certain matings are known to live well, while those from different matings, kept under identical conditions, have high mortality. Livability is inherited. It may also be influenced greatly by environment. It is a good practice to use only breeders whose progeny live well.

Progeny. The final proof of a bird's value as a breeder is its ability to transmit desirable characters that it possesses to its offspring. Selection of female breeders on the basis of their first year trap-nest records failed to improve egg production in the Maine Experiment Station flock. When selection of cockerels and pullets for breeders was made on the basis of their offspring's record, a steady increase in production was obtained.

Systems of Breeding Poultry

Once individual breeders have been selected, they are bred according to one of two systems, inbreeding or crossing or modifications of them.

Inbreeding. Inbreeding is the mating together of relatives. Since there are different degrees of relationship, there are also different degrees of in-

breeding. The term "close inbreeding" is used to refer to the mating of brothers and sisters or parent to offspring.

The purpose of inbreeding is to intensify desirable characters—that is, to secure them in more homozygous condition. Inbreeding is used on poultry farms to develop lines which when crossed will give progeny with high egg production, large eggs, good meat type, good livability, etc.

Inbreeding may result in reduced vigor and a decline in hatchability unless the birds are selected for good vigor and hatchability, as well as the particular character that is to be improved. It must be remembered that, if a bird is selected for a good character and it should happen to have a bad one and if it is inbred to intensify the good one, the bad one will also be intensified.

At the University of Wisconsin, Rhode Island Red pullets and cockerels were selected on the basis of plumage color. Vigor, egg production, and hatchability were not considered. After four years of inbreeding, in which brother and sister matings were used, the experiment had to be discontinued because of the decline in vigor, egg production, and hatchability. The decline in hatchability is shown in Table 4–5.

Table 4–5

INFLUENCE OF CLOSE INBREEDING ON HATCHABILITY AMONG RHODE ISLAND REDS [a]

Mating	First Year	Second Year	Third Year	Fourth Year
	Per Cent			
Inbred line..........	67	49	41	18
Control line..........	67	31	56	64

[a] Cole and Halpin.

Inbred poultry, according to the National Poultry Improvement Plan (page 106) is the first generation poultry, chicks, or eggs, produced by a mating of poultry of known relationship, related to the degree of first cousins or closer.

Inbred line is a group of inbred poultry, or chicks, or eggs, resulting from at least four generations of inbreeding. The poultry constituting the line must be individually identified as to origin and so interrelated that the mating of any pair within the line would result in progeny with an amount of inbreeding of 37.5 per cent (equivalent to two generations of brother-sister matings).

Coefficient of inbreeding is the measurement of the decrease in heterozygosity. It is exactly one-half of the relationship between the parents unless these parents are themselves inbred, in which case some correction should be made. For instance, if a bird is heterozygous for 100 pairs of genes and it is inbred so that its inbreeding coefficient is 25 per cent, it will probably be heterozygous for only 75 pairs of genes. The formula for determining the coefficient of inbreeding is complicated and need not be considered here.

Cross breeding: This includes : (1) The crossing of two different breeds or varieties. (2) Crossing first generation poultry resulting from the combination of two different breeds or varieties with another and different breed

or variety. (3) Crossing the first generation poultry resulting from the combination of two different breeds or varieties with the first generation poultry resulting from the combination of two other different breeds or varieties.

Crossing is used to identify the sex of chicks at hatching time and to produce chicks for commercial broiler and egg production. It may result in better hatchability, livability, and growth rate of chicks (Table 4–6). Results

Table 4–6

INFLUENCE OF METHOD OF BREEDING ON PERFORMANCE OF FOUR GENERAL PURPOSE BREEDS OF POULTRY[a]

Observations (Average of Three Years)	Pure Strain (Inbreeding)	Strain Cross	Crossbred
Fertility, %	82.3	79.9	85
Hatchability, %	76.7	76 0	81
8 wk. wt. of cockerels (grams)	628.0	678.0	709
8 wk. wt. of pullets (grams)	600.0	625.0	641
Brooder and range mortality, %	37.0	30 0	28 0
Laying house mortality, %	33.0	30.0	31.0
Egg production, %	41.0	45.0	46.0
March egg weight grams	60 0	59.3	59.3
March body weight, lbs.	6.1	6.4	6.4

[a] Nordskog and Ghostley—1954.

obtained may be expected to vary with the breeds or varieties crossed and also their purity. Crosses should be tested to determine the value of their progeny before being produced in large numbers.

Hybrid chickens as used at present refers to stock produced by crossing of breeds with or without previous inbreeding.

Strain crossing is a form of breeding in which one family line is crossed with that of another of the same variety. The object is to hold the good traits already in the one family line and to capture the good ones from the other one. Or, it may be to attempt to get rid of the undesirable traits in one line and obtain only the good ones from another line.

Recurrent reciprocal selection is much like strain crossing but differs from it in the way the pure strains are multiplied. They are multiplied not on the basis of their own performance but by using those individuals which cross best with the other line (Fig. 4–15).

Step 1—Cross strains A males with B females
A females with B males
2—Measure performance of the crosses.
3—Pick out best A and B breeders (Step 1).
4—Reproduce the best A x A and B x B birds.
5—Cross the AA and BB birds.

Topcrossing is a form of strain crossing in which an inbred male of one strain is mated with a non-inbred female of another strain.

Recurrent selection is a form of top crossing in which selection is made in the non-inbred line on the basis of the progeny produced from mating with an inbred line.

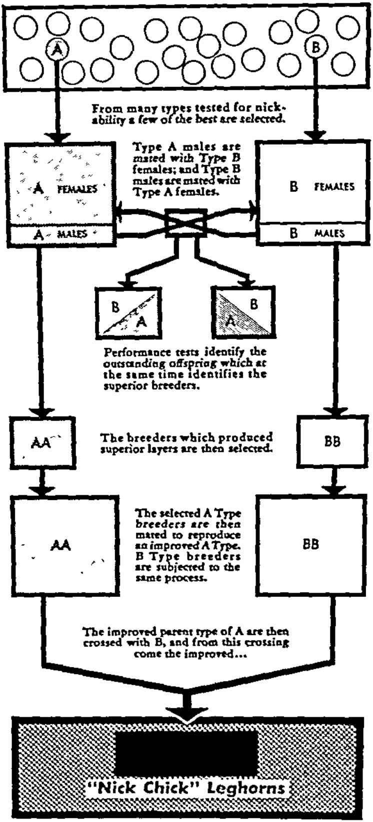


Fig. 4-15. Breed improvement by reciprocal recurrent selection (after Heisdorf and Nelson Farms, Kirkland, Washington).

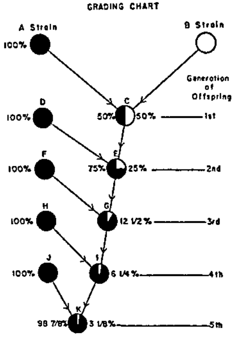


Fig. 4–16. Flock improvement by the purchase of improved males (outgrading).

Outgrading is a breeding plan used by many commercial hatcheries to improve the quality of the chicks sold. They buy improved males of some breed or variety, Single-Comb White Leghorns for instance, and place them in hatchery flocks comprised of Single-Comb White Leghorns (Fig. 4–16). The object is to improve the quality of the chicks produced from the flocks.

Backcrossing is the mating of a crossbred animal back to one of the pure parent races which were crossed to produce it. It is not widely used in poultry breeding.

Incrossing is: (1) The crossing of two inbred lines of the same or of different breeds or varieties. (2) The crossing of first generation poultry resulting from the combination of two other inbred lines when each line used is of different breed or variety than any other used. The production of commercial incrossbreds is usually accomplished by this method (Fig. 4–17). Some incrosses improve the quality of the resulting stock while others do not. The problem is to find desirable combinations of inbred lines for making desirable crosses.

Closed flock breeding. This system of breeding begins with the selection of individuals and families within a flock. The individuals from different families are mated. No new strains of stock are introduced. No crossing is practiced except between the different families within the flock. The objective of the closed flock system of breeding is to combine or intensify the desirable characters in the different families within the flock and at the same time reduce or eliminate the undesirable ones.

Methods of Mating

The method of mating used will have a marked influence on fertility and consequently on the number of offspring used. The two most common methods of mating are flock and pen mating. Stud mating and artificial insemination are sometimes used in experimental work.

Flock mating. Flock or mass mating means that a number of males are allowed to run with the entire flock of hens. This system of mating is used on most farms. In flock matings the percentage of the chicks hatched is unknown.

Other things being equal, better fertility is obtained from flock matings than from pen matings. There is an opportunity for birds to mate with those

Inbred Leghorns (3 generation Bro. X Sis. equivalent or more)	Inbred Rhode Island Red (3 generation Bro. X Sis. equivalent or more)
Male of Line A X Female of Line B	Male of Line C X Female of Line D
↓	↓
AB	CD
Incross Leghorn Males (Flock Owner Males)	Incross Rhode Island Red Females (Flock Owner Females)

↘ ABCD ↙

Incrossbreds
(Commercial hybrid chicks No. *00*)

COURTESY R. GEORGE JAAP

Fig. 4–17. Production of incrossbred hybrids.

they like in flock mating; in pen mating there is no choice. Competition among males in flock mating also results in more matings and better fertility.

The number of hens that should be mated with each male will vary with the size and age of the birds (p. 94).

Pen mating. In pen mating a pen of hens is mated to a single male. If the birds are trap-nested and the hen's leg-band number recorded on the egg, it is possible to know the parents of every chick hatched from a pen mating.

About the same number of hens are mated with a male as in the case of flock mating. Fertility is generally not so good in pen mating as in flock mating. This is because certain hens may not like the male, or vice versa.

Stud mating. In stud mating the females are mated individually with a male kept by himself in a coop or pen. In this system of mating more females can be mated with a male than in pen matings. Stud mating involves more labor than flock or pen mating. The birds should be mated at least once each week in order to maintain good fertility.

Stud mating may be used when a very valuable male is being used as a breeder. By the use of stud mating, more offspring can be obtained from the male.

Artificial insemination. Artificial insemination is possible but not practical in ordinary poultry-breeding work. It is used in experimental work with hens kept in cages and may be used in turkey breeding where poor fertility is encountered.

A method has been developed at the National Agricultural Research Center and elsewhere for securing sperm from the male by artificial stimulation and for transferring it to the oviduct of the female. Doses of .1 cc. of semen injected once a week give good fertility.

Securing Good Fertility

Once high egg production has been secured, fertility is the first factor which determines the number of offspring that may be obtained from a given individual. As in the case of other animals, both males and females among poultry may be sterile. It is a good plan to test the fertility of males and females at least a month before the beginning of the breeding season. Factors influencing fertility include the number of females mated to one male, the age of breeders, the length of time between mating and saving eggs for hatchability, and management practices.

The number of birds mated to one male. In mating birds of the light or egg breeds, such as Leghorns, it is customary to use one male for fifteen to twenty hens. In case of the general-purpose breeds, such as Plymouth Rocks, it is customary to use one male with ten to fifteen hens. About eight to twelve hens are mated with one male in case of the heavy breeds, such as the Brahmas.

Age of breeders. Young birds are more active than old ones. Fertility is better among pullets and cockerels during the first year than later on. Males are not very satisfactory as breeders after they are about three years old.

Fertility can be improved by using cockerels with old hens or pullets with old males. When both old hens and old males are used in the breeding pen, fewer hens should be used with each male than generally recommended.

Length of time after mating. It is possible to secure fertile eggs about twenty-four hours after males have been placed in the pen. However, a maximum percentage of fertility is not reached until about ten days after the birds have been mated.

It is possible to secure fertile eggs as long as twenty-one days after the males have been removed from the flock. Reasonably good fertility may be expected for about a week after removal of the males. In case a male bird dies or is replaced by another male in a breeding pen, one should wait about three weeks before saving eggs for hatching in order to be sure that none of the eggs were fertilized by the sperm of the preceding male.

It is true that when other things are equal, the newest sperm in the oviduct will be most likely to fertilize the eggs.

Influence of flock management. The health of the flock and housing conditions influence fertility. Good fertility cannot be expected unless the birds are vigorous and active.

Extremely cold weather will result in poor fertility and poor hatchability unless housing conditions are such that the birds will be comfortable. In cold climates, where breeders are kept in unheated pens, it is a good plan to dub the combs and wattles of the males to prevent freezing. Birds with frozen combs or wattles are inactive because of the soreness of the affected parts.

The poultry house should be kept clean, dry, well ventilated, and free from filth.

Breeding for Hatchability

It is known that feeding and management practices affect hatchability. Aside from these, there are a number of breeding practices which influence hatchability. Chief among these may be mentioned the age of breeders, egg production, method of breeding, egg characters, and lethal genes.

Age of breeders. Eggs from pullets show a little better hatchability of fertile eggs than those from hens. Since fertility of eggs from pullets is higher than that from hens, the number of chicks obtained from each one hundred eggs set is higher from pullets than from hens. This fact tempts some hatcherymen to hatch from pullets rather than from hens. The chicks from pullets will not be so large or uniform as those from hens.

The University of Missouri has made a study of the hatchability of eggs from hens and pullets, comprising several different breeds. The results are summarized in Table 4–7.

Table 4–7

THE PER CENT HATCHABILITY OF PULLET AND HEN EGGS [4]

Breed	Pullets	Hens
White Leghorns	83	75
Rhode Island Reds	79	71
Barred Plymouth Rocks	62	57
White Plymouth Rocks	76	69

[4] Funk.

The hatchability of eggs of the same group of birds used two or more breeding seasons in succession tends to decline. Studies made at the Kansas Experiment Station are summarized in Table 4–8.

Table 4–8

PER CENT HATCHABILITY OF EGGS FROM THE SAME GROUPS OF BIRDS IN SUCCEEDING YEARS [5]

Breed	Pullet Year	Second Year	Third Year	Fourth Year
White Leghorns	75	66	70	..
White Leghorns	..	78	72	61
Rhode Island Reds	60	53	49	...
Rhode Island Reds	...	69	66	54

[5] Warren.

Egg production. Good hatchability is associated with good egg production. There is a common belief that if birds have been laying very long before the hatching season, hatchability of eggs and livability of chicks will be

lower than from birds that have not laid so many eggs. A study of this factor was made at the National Agricultural Research Center. The results are summarized in Table 4–9. From it, one may conclude that the length of time

Table 4–9

EFFECT OF PREVIOUS PRODUCTION ON HATCHABILITY AND LIVABILITY OF CHICKS [6]

Previous Production of Birds from October to Hatching Season	Per Cent Hatchability of Fertile Eggs	Per Cent Chick Mortality First Four Weeks
Barred Plymouth Rocks		
Those laying 0–29 eggs	77	4
30–59 eggs	72	3
60–89 eggs	71	...
Rhode Island Reds		
0–29 eggs	73	1
30–59 eggs	71	2
60–89 eggs	64	...
White Leghorns		
0–29 eggs	74	3
30–59 eggs	73	3
60–89 eggs	69	2

[6] Jull.

birds have been in production before the hatching season does not influence the hatchability of the eggs set or the livability of the chicks hatched.

Methods of breeding. Hatchability is influenced by the method of breeding. Close inbreeding tends to lower hatchability (p. 89), while crossbreeding increases it. If birds are selected for high hatchability as well as for the character to be intensified in line breeding, no harm results from this system of breeding.

Egg characters. Egg characters, such as size, shape, and interior quality, affect hatchability.

Standard-weight eggs, those weighing two ounces each, hatch better than those much above or below this weight.

Long pointed and short bulging eggs do not hatch well. They should be culled out from eggs that are to be used for hatching purposes anyway. If a pullet is hatched from such an egg, it will likely lay the same kind. Long pointed and short, thick eggs are unsatisfactory for packing for market.

Double-yolked eggs seldom hatch. Embryos may develop in such an egg until near the hatching day The chicks are too cramped and there is not enough space for respiration and movement in the pipping process.

Eggs with shells of medium strength hatch better than eggs with shells that are too thick or too thin. Evaporation is too rapid from thin-shelled eggs during the period of incubation. Chicks have difficulty in pipping in eggs with extremely thick shells.

Eggs with good interior quality, as judged by candling appearance, hatch

better than those with poor interior quality. Eggs with a large proportion of white in proportion to yolk do not hatch so well as those with less white.

Records were obtained on the relationship between the candling grade of eggs and their hatchability in connection with chicks produced for the Annual Baby Chick Show, held at Ohio State University. Some of the data obtained are summarized in Table 4–10.

Table 4–10

INFLUENCE OF EGG QUALITY ON HATCHABILITY

Quality of Eggs	1938	1939	1940	Total for Three Years
Grade A				
Number set	1147	4547	5825	11519
Number chicks hatched	825	3364	4192	8381
Per cent hatch of eggs set	72	74	72	73
Grade B				
Number set	1733	2155	1001	4889
Number chicks hatched	1229	1550	744	3523
Per cent hatch of eggs set	71	72	74	72
Grade C				
Number set	97	30	4	131
Number chicks hatched	50	19	1	70
Per cent hatch of eggs set	52	63	25	53
Blood and Meat Spots				
Number set	9	19	37	65
Number chicks hatched	4	11	23	38
Per cent hatch of eggs set	44	58	62	58
Checks				
Number set	14	30	2	46
Number chicks hatched	4	16	1	21
Per cent hatch of eggs set	29	53	50	46

Lethal genes. Lethal genes affecting hatchability have been discovered in recent years (p. 78). In studying hatching records on breeding farms, the dead embryos should be examined in order to locate sires and dams carrying the lethal genes in heterozygous condition. A sire and a dam each carrying a lethal gene in a heterozygous condition will produce offspring in the proportion of three normal to one carrying the lethal character. The same sire, mated to his daughters, produces five normal to one lethal or seven normal to one lethal embryo.

Hatchability improvement through breeding can be secured only by trapnesting and selection of individuals and families. The farmer who experiences low hatchability as a result of breeding can improve it by the use of males which were produced by families having high hatchability.

Breeding for Livability

Livability is influenced greatly by feeding and management practices. It is also influenced, in many cases, by low resistance of the stock to disease invasion.

Experimental evidence has shown that there are family differences as regards the susceptibility to and resistance against pullorum, fowl typhoid, range paralysis, roundworm infestation; crooked keels, and reproductive troubles.

Breeds and strains. Chicks obtained from different breeds and strains but reared under identical conditions show marked differences in livability (Table 4–11).

Table 4–11

VARIATION IN PERFORMANCE OF 27 BREEDS, STRAINS AND CROSSES FOR BROILER PRODUCTION [7]

Observation	Average	Range
Production, Hen housed %	48.5	31.9–62.8
Hatching eggs, % of total	96.7	92.0–98.6
Lbs. feed per dozen eggs	8.7	6.7–12.8
Mortality of layers, %	9.7	0.0–42.5
Hatchability of eggs set, %	74.3	55.2–83.1
Fertility of eggs set, %	85.0	76.9–95.4
Progeny at 10 wks.		
Av. wt. of females	2.9	2.6– 3.2
Av. wt. of males	3.7	3.3– 4.1
Mortality, %	4.0	1.0–12.3
Lbs. feed per lb. of gain	2.4	2.2– 2.5

[7] 11th Georgia broiler-breeder test 1956–57.

System of breeding. Inbreeding results in reduced vigor and increased mortality (p. 89). Crossbreeding has the opposite effect. If care is used in the selection of breeding stock for livability, as well as for the character to be intensified, some inbreeding may be practiced without harmful effects on livability.

In breeding for livability, only birds from families that have shown good livability should be used. Theoretically, at least, it would be possible to improve livability by the system of breeding known as outcrossing (p. 92). The use of males from families that have shown good livability reduces adult mortality.

Breeding for Growth and Feathering

Rate of growth and adult body size are both inherited characters. They may be influenced greatly by the selection of breeding stock (Table 4–11). The rate of growth of body flesh and feathers is also influenced by the protein

Fig. 4–18. Chicks showing contrasting feather growth. Left, slow feathering chick at age of 10 days: right, fast feathering chick at same age. (U. S. D. A. Leaflet 233.)

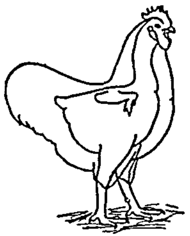
and vitamin content of the ration (Chapter Eight) and the temperature used in brooding.

Within a given breed or variety it has been observed that some strains grow much faster and reach sexual maturity earlier than others. Strains with narrow feathers generally mature more slowly than those with broad feathers. Birds with narrow feathers in the Barred Plymouth Rock and Rhode Island Red breeds may produce chicks that have bare backs most of the time during the first six to eight weeks of the growing period.

The breeding stock should be selected on the basis of the rate of growth up to eight weeks if it is desired to increase rate of growth. The young stock should be inspected for weight and feathering at this age. Underweight and poorly feathered birds should be removed or marked and removed later on. If the records on growth and feathering are not recorded until the birds are housed, many of the undesirable birds will be missed. They will have completed a normal plumage and possibly will have grown to normal size by the time they are placed in the laying house.

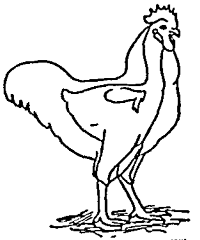
Early-feathering chicks are found within a breed and strain as indicated by the length of the wing and tail feathers at about ten days of age (Fig. 4–18). By picking out these chicks and using them as breeders, it is possible to develop an earlier-featherng strain of birds.

Crossbred poultry generally make better growth during the first eight to



COURTESY CANADA DEPARTMENT OF AGRICULTURE

Fig 4–19. A good body type for meat production. The legs are short; the breast broad; and the keel is carried well forward.



COURTESY CANADA DEPARTMENT OF AGRICULTURE

Fig. 4–20. A poor body type for meat production. The legs are long; the breast shallow; and the body is short and narrow.

twelve weeks than the Standard-bred birds from which they were hatched (Table 4–6). The adult size is generally intermediate between that of the two breeds that were crossed. Data obtained at the California Experiment Station indicate that the shank length measurement of live birds is a true indication of heritable differences in body size.

Breeding for Meat Production

Breeding chickens for meat production has been overshadowed by breeding for egg production. As we shall see, selection of birds for egg production is very complicated. Very little may be learned about the egg production of a hen by looking at her. It is quite different in selecting birds for meat production. Birds are selected for type in breeding for meat production.

Extensive studies have been made in Canada on the selection and breeding of birds for meat production. Contrasts in good and poor types for meat production are shown in Figures 4–19 and 20. Good birds have a broad back and the keel is carried well forward. The legs are short and thick and set well apart. The neck is short. Poor meat-type birds have narrow backs and shallow breasts; the legs are long, thin, and close together. Birds selected as breeders for meat production should have shown rapid growth and good feathering during the first eight weeks Variations in meat-type breeds, strains and crosses are shown in Table 4–11.

Breeding for Egg Production

Most of the income from chickens is from the sale of eggs for food and for hatching purposes. The higher the egg production secured, the lower the

feed and total cost per dozen of eggs. Consequently, poultrymen are interested in high egg production. Good feeding and management practices will result in an increase in egg production from about 80 or 90 eggs per year to 150 or 160. Greater production will depend largely on careful selection of breeders on the basis of the trap nest, sib, and progeny records (Tables 4–12 and 13).

Table 4–12

THE AVERAGE FIRST-YEAR PRODUCTION OF THE DAUGHTERS OF DAMS CLASSIFIED ACCORDING TO THE RANGE IN EGG PRODUCTION OF THE DAMS [8]

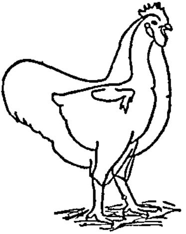
Range in Egg Production of Dams	Average Egg Production of Daughters	
	Rhode Island Reds	White Leghorns
181–190	.	162
191–200		157
201–210	188	168
211–220	205	161
221–230	192	173
231–240	192	176
241–250	199	169
251–260	201	188
261–270	200	209
271–280	197	188
281–290	179	208
291–300	...	222
301–310	...	228
311–320	...	220

[8] Jull.

Selection on the basis of the trap-nest record. Inherited characters for high egg production include early sexual maturity, rate of production, lack of pauses, nonbroodiness, and persistency in production. Accurate records regarding these characters can be secured only through trap-nesting the birds. Once prospective breeders have been selected on the basis of vigor and breed and variety characteristics, they should be leg-banded and trap-nested; and the records should be analyzed on a family basis before the breeders are selected.

Early maturity. Early sexual maturity, the age at which egg production begins, is an inherited character. It shows dominance and some sex linkage in which several genes are probably involved. By selecting the early-maturing birds in a flock each year, it is possible to materially reduce the time required to reach sexual maturity in a flock. At the Kansas Experiment Station the time required for a strain of Rhode Island Reds to reach sexual maturity was reduced from 269 to 222 days in the course of six years of selection and breeding for early maturity.

If light breeds, such as Leghorns, are to lay approximately 250 eggs during the pullet year, they should come into production when about five months



COURTESY CANADA DEPARTMENT OF AGRICULTURE

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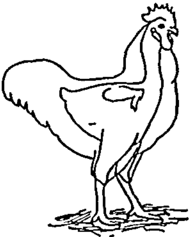

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If light breeds, such as Leghorns, are to lay approximately 250 eggs during the pullet year, they should come into production when about five months

old. In the case of general-purpose breeds, such as Rhode Island Reds, production should start when the birds are about six months old.

In a flock of birds in which all of them are the same age, the first 75 per cent that come into production will be the best layers.

Rate of production. A bird that lays at a high rate has a shorter interval between ovulations, the eggs remain in the oviduct for a shorter period of time, and laying takes place more nearly at the same hour each day than in the case of a low-rate layer. In other words, the best layers lay in long clutches with few intervals, while the poor layers lay in short clutches with numerous intervals of varying length between the clutches. At the National Agricultural Research Center it has been observed that full sisters lay at more nearly the same rate than half sisters and less related birds, and half sisters lay at more nearly the same rate than less related birds.

The rate of production is figured on a percentage basis, using the number of eggs laid from the date of the first egg to a given date in relation to the total number of days involved. If a flock of birds is to average about two hundred eggs during the first year of production, they should lay at the rate of 60 per cent, or at least four eggs per clutch.

Lack of pauses. Some birds lay well for a while and then go out of production for varying lengths of time. A pause is regarded as an interval of more than seven days between clutches of eggs. Some pauses may be caused by digestive disturbance, a cold or other respiratory trouble, parasites, etc. Other pauses are encountered which cannot be accounted for on the basis of disease, environment, and management. They are believed to be hereditary. One of these pauses is encountered during the winter and is commonly referred to as the winter pause.

In selecting birds to be used for breeders, those with the fewest pauses and of the shortest duration should be selected.

Nonbroodiness. If a bird is to lay well, it must not be broody much of the time. Broodiness is partially determined by a dominant sex-linked character. Unless breeders are selected for nonbroodiness, the offspring will show more broodiness each year with a decline in egg production.

Light breeds, such as Leghorns, are less broody than general-purpose breeds, such as Plymouth Rocks. Within a given breed or variety there are strains with much less broodiness than is found in others.

When two breeds are crossed, the progeny generally show more broodiness than that shown by either of the parent breeds.

A record should be made of each period that a bird is broody. If the broody period is often or of long duration, the bird should not be used in the breeding pen. It is a common practice to reject Leghorns that are broody two or more times during the year, as well as general-purpose birds that are broody three or more times.

Persistency in production. Persistent layers are those that lay well during the summer and fall of the year following that in which they were hatched.

The termination of the first year of laying is closely related to the first annual molt. Most birds quit laying and then molt. A few birds will lay and

molt at the same time; these are usually very desirable birds for use in the breeding pen.

Birds should be selected for persistency of production that lay approximately twenty-five eggs during August and September of the year following that in which they were hatched.

At the Massachusetts Experiment Station, Rhode Island Red breeders were selected for egg production for eighteen years on the basis of early maturity, rate of laying, nonbroodiness, and persistency. The days required to reach sexual maturity were reduced from 200 to 196; rate of lay (clutch size) increased from 54 to 92 per cent; persistency of production increased from 331 to 343 days; and average annual egg production increased from 200 to 221. Similar results are being obtained today but at a faster rate by the use of larger numbers of families of birds.

Selection of breeders on the basis of the first year of egg production alone is not a satisfactory measure of their breeding value (Table 4–12).

Selection on the basis of the family records. A bird with a good pedigree or family history of good production is to be preferred to one whose pedigree is unknown. A study of the egg-production records of ancestors back as far as three generations is useful in estimating the breeding value of an individual. However, the records of the brothers and sisters are as important or more so than that of the parents and grandparents in predicting the breeding value of a male or female.

Selection on the basis of the progeny test. Performance of the individual is valuable in breeding for improvement in characters of high heritability such as growth rate, body conformation, and egg weight. Family and progeny records are essential in breeding for improvement in characters of low heritability such as egg production, hatchability, and viability. The final and most valuable test for a breeder is the kind of progeny that it produces. It is not how many eggs a hen lays that counts, but the number her daughters will lay. If a bird is to be valuable as a breeder, it must be able to transmit desirable characters to its offspring.

Poultry-breeding work at the Maine Experiment Station became the foundation for modern poultry breeding and progeny testing. Nine years of poultry breeding in which females were selected for breeders on the basis of their first-year trap-nest records failed to produce an increase in the level of egg production among the pullets raised each year. When pullets and cockerels were selected for breeders each year from among the best families of that year, a steady increase in the level of egg production was achieved.

It is highly important to select sires of superior breeding value because the average sire has about ten times as many chicks as the average dam. Some actual case records are presented in Table 4–13. Sire Number 1 is far more valuable than Number 3 as a breeder, even though his mates did not have quite so high an egg production.

In carrying on a progeny test program the first step is to determine which of the different male birds used proved to be the best breeders. The daughters of each male should be compared with those of other males with respect

Table 4–13

VARIATIONS IN EGG PRODUCTION OF DAUGHTERS OF DIFFERENT SIRES AND DAMS

Sire or Dam Number	Average Production of Mates or Self	Number of Daughters	Average Egg Production of Daughters
Sire 1	264	76	219
Sire 2	276	108	191
Sire 3	285	114	163
Dam 4	281	8	278
Dam 5	312	19	203
Dam 6	234	11	186

to sexual maturity, rate of laying, lack of pauses, nonbroodiness, and persistence of production. Having determined the best males, the next step is to determine the female progeny of each of the hens to which a superior male was mated.

The breeding program should be based on the selection of outstanding families Sires and dams of outstanding value should be used as many years as possible. Their progeny should also be given preference when selecting future breeders.

Since the life of chickens is relatively short, and their breeding period pretty well over by the time records on the progeny are known, the records of the full sisters are given considerable weight in selecting cockerels for the breeding pen. If the first part of the pullet laying year is outstanding, as judged by sexual maturity, rate of laying, lack of pauses, and nonbroodiness of all the sisters in the family, the brothers can be used as breeders that year with a good degree of assurance that they will prove satisfactory.

Selection on the basis of long-time egg production. Birds that lay well the first year have a tendency to do so the second year. There are some notable exceptions, however. Naturally a bird that lives and continues to lay well for two, three, or four years is more desirable as a breeder than one with a shorter record of production.

Under ordinary circumstances, the decline in egg production is about 20 per cent of that of the preceding year. For instance, if a bird laid 200 eggs during the pullet year, it may be expected to lay about 160 eggs the second year and 130 the third year. If the first-year egg production has been retarded by improper feeding or management, a bird may lay more eggs the second year than during the first one if the poor management practices are corrected.

Breeding for Egg Quality

The number of eggs laid is not the only thing to be considered in breeding for egg production. The markets and consumers are interested in egg size and shape, shell color and texture, and interior quality (Table 4–14).

Table 4–14

REPORT OF 8TH NEW YORK RANDOM SAMPLE EGG LAYING TEST, MAR. 1, 1957–JULY 14, 1958 (33 ENTRIES)[9]

Observation	Average	Range	Average of 2nd. test
Egg production. Hens housed	—214	173–236	172
Egg production. Hen-day	—227	190–253	207
Egg size. Ounces per dozen.	26.2	25.0–27.8	
Sexual maturity. Days to 50% production.	180	172–192	184
Mortality. Eight to 500 days.	% 13.9	2.0–42.5	40.8
Mortality from neoplasms	% 6.6	0.0–20.0	19.8
U. S. D. A. Scores of albumen in June	3.7	2.9–5.1	4.8
Per cent blood and meat spots	9.4	4.0–18.0	12.1
Feed per dozen eggs. Lbs.	4.7	4.3–5.5	6.2

[9] D. R. Marble, Supervisor Random Sample Test, Cornell University, Ithaca, New York.

Egg size. Egg size is correlated with body size within the breed and strain. Egg size increases from the time pullets start to lay in the summer or fall until the month of February. The size of eggs declines during the hot summer months. Eggs produced during the second year of production are larger than first-year eggs. Those laid at the beginning of a clutch are larger than those laid at the end. There is also a tendency toward a decline in egg size with the total number of eggs laid in a year.

It is possible to secure and maintain good egg size even with high egg production by mass selection of breeders that have good body and egg size as well as good egg production.

Eggs of uniform shape weighing between twenty-four and twenty-eight ounces per dozen, should be set in order to maintain standard-weight eggs of twenty-four ounces per dozen in the succeeding generation. There is a tendency for birds to revert to the laying of small eggs like those of their ancestors, unless one continually selects eggs of good size for hatching.

Leghorns should weigh at least three pounds, Rhode Island Reds four and one-half pounds, and Plymouth Rocks five and one-half pounds at the time production begins, if good egg size is to be obtained. The size of the pullet, rather than the age at which it starts to lay, is the more important factor influencing egg size.

Shell color. Shell color is more important in white eggs than in brown ones. Varying shades of color are expected among brown eggs. Tinted shells should be avoided among white eggs; they do not influence the food value of the eggs, but do have an unfavorable effect on the appearance of packs of white eggs. White eggs that have tinted shells should not be set. Birds that lay eggs with tinted shells or poor shell texture should not be used for breeders. The use of the trap nest enables one to detect the birds that lay undesirable eggs.

Eggshell texture declines with age and the length of the laying period. A breeder may have laid eggs with good shell texture in the pullet year and

with thin or rough shells in later years. Shell thickness declines toward the end of the laying year, often becoming quite poor in the late summer. Birds should be selected for breeders that lay well during the months of August and September, and that produce good shells during this period.

Interior quality. Interior quality of eggs is influenced by breeding (Table 4–14). The percentage of thick white to total white, presence of blood spots, and possibly yolk color, are influenced by the genetic constitution of the bird. Hatching eggs should be graded for size and shape, and candled for shell texture and interior quality.

The National Poultry Improvement Plan

Most states have had some kind of breed improvement programs for a number of years. Some have been supervised by state regulatory agencies, some by poultry extension service agencies, and others by dues paid by members of the association. The programs have lacked uniformity in terminology and supervision.

In 1935 the United States Department of Agriculture established the National Poultry Improvement Plan in co-operation with state poultry improvement associations. The objectives of the plan are to improve the breeding and production qualities of poultry and to reduce losses from pullorum and typhoid diseases. This is being accomplished by (1) the development of more effective state poultry improvement programs; (2) the identification of the quality of breeding stock, hatching eggs, and chicks by authorized terms that are uniform and applicable in all parts of the country; and (3) the establishment of an effective co-operative program through which newer knowledge and practical experience can be applied to the improvement of poultry and poultry products.

Acceptance of the plan is optional with the states and with individual members of the industry within the states. The plan is administered in each state by an official state agency, co-operating with the Animal and Poultry Husbandry Research Division, Agricultural Research Service, United States Department of Agriculture.

The National Poultry Improvement Plan is divided into two parts: breeding stages and pullorum control and eradication classes.

Breeding stages. 1. *U. S. Approved.* All males and females are selected by Authorized Agents according to standards prescribed by the State College of Agriculture.

2. *U. S. Certified.* (a) *Eggs.* All males ROP or all males and females from ROP Performance Tested Parent stock for egg production. (b) *Meat.* Same requirements as for eggs except the stock is tested for meat production.

3. *U. S. Record of Performance (ROP).* (a) *Females.* (1) an individual that has laid at the rate of 60 per cent or more during a period of at least 10 consecutive months, when trap-nested a minimum of five days per month and at least 100 days. (2) Members of an entire family of six or more full sisters that have laid at an average rate of 65 per cent or more during a period of at least 10 consecutive months, when trap-nested as above. (b) *Males.* Pro-

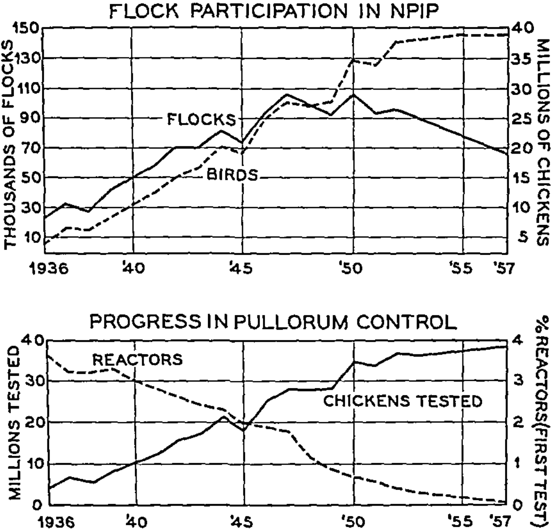

Fig. 4–21. Flock participation and pullorum testing under the National Poultry Improvement Plan, 1936–1958.

duced from an ROP sire and ROP dam in a single male mating. The birds must be vigorous, free from disease symptoms; representative of the breed and variety; and free from serious defects such as abnormal eyes, crooked beak or back, seriously crooked breast bone, or toes, wry tail; and underweight as defined for disqualifications in the Standard of Perfection.

4. *U. S. ROP Tested Parent Stock.* (a) *Egg production.* Progeny entered in an officially recognized central random sample egg production test and ranked in the top two-thirds of the entries, based upon income above feed and chick costs per pullet chick started. (b) *Meat production.* Progeny entered in an officially recognized central random sample meat production test that laid at an average rate of at least 50 per cent on a hen-housed basis and had an average 9-week weight of at least 2.5 pounds for pullets and 3 pounds for cockerels or ranked in the top third of the entries in rate of lay and rate of growth.

The minimum weight of hatching eggs sold for all breeding classes shall be $1\frac{11}{12}$ oz. each for replacement stock and $1\frac{10}{12}$ oz. each for broiler stock.

COURTESY OHIO POULTRY IMPROVEMENT ASSOCIATION

Fig. 4–22. Trap-nesting. The bird and egg are removed from the nest and the egg recorded on the trap-nest record sheet.

Pullorum and Typhoid Control Classes. Pullorum and typhoid are two closely related bacterial diseases (p. 320) that may be transmitted from the breeding hen to the baby chick, through the hatching egg, and result in high mortality of chicks, the first three weeks. The disease may be detected by a standard tube, rapid serum or stained antigen whole blood test. The test is made by an Authorized Agent. Tests must be made at last three weeks and not more than one year apart. Chickens must be at least five months old when tested.

1. U. S. *Pullorum—Typhoid Passed.* Flocks in which no pullorum or typhoid reactors were found on the last official blood test.

2. *U. S. Pullorum—Typhoid Clean.* Flocks in which no pullorum or typhoid reactors were found on two consecutive official blood tests.

Accomplishments of the Plan. The average annual egg production in the United States increased only seven eggs during the twenty-five-year period before the National Plan was started. During its operation the average annual egg production has increased rapidly (Fig. 1–8).

The per cent of pullorum reactor chickens in flocks when official pullorum testing was started in the United States in 1920 was about 11 per cent. By 1957 it had been reduced to about 0.045 per cent (Fig. 4–21). Since the National Plan was started, the number of breeders tested has increased from about 2.5 million to about 39 million.

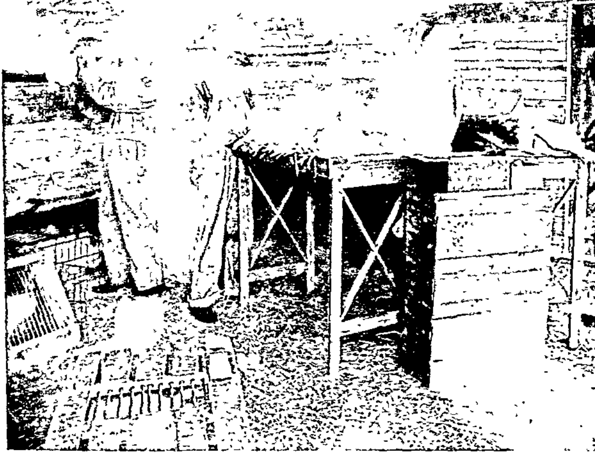

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Fig. 4–23. Selecting birds for the breeding flock; pullorum testing by the whole blood method; and banding approved birds.

Poultry-Breeding Records

The efficiency of any poultry-breeding program will depend on the completeness and accuracy of the records kept. They are essential for selection of breeders on the basis of production, reproduction, family and progeny performance. The United States Department of Agriculture, in co-operation with the state poultry improvement associations, has developed a system of records for use in the National Poultry Improvement Plan. The simplest breeding records used in connection with the record of performance are (1) the monthly trap-nest record, (2) yearly summary sheet, (3) the breeding-pen record, (4) incubation and chick-banding report, (5) pedigree record, and (6) the female summary record.

The monthly record. Trap-nesting is costly because it requires about twice as much labor to care for birds. Therefore, in starting a poultry breed improvement program, one should first have a healthy flock of Standard-bred birds with good flock-production records.

The birds to be trap-nested should be selected from the flock, blood-tested, and leg-banded with a sealed band (Fig. 4–23). The birds should be trapped every hour during the morning and every hour or so during the afternoon (Fig. 4–22). When the bird is removed from the nest, the egg is recorded on a monthly record sheet (Fig. 4–24).

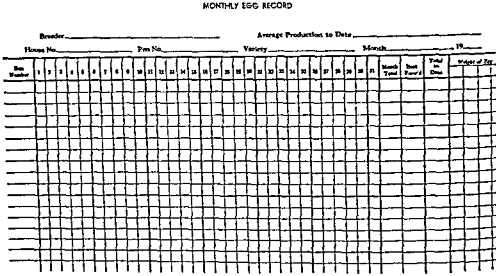


Fig. 4–24. Monthly trap-nest record sheet.

The various characteristics listed at the top and right of the form should be recorded in order to supply as much information regarding individual layers as possible.

The monthly record forms are large enough to provide for the recording of the monthly production of twenty-five to fifty hens.

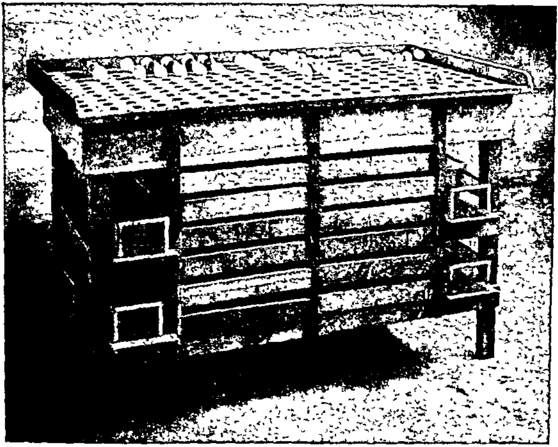
The yearly summary sheet. The monthly egg production and characteristics of each bird are transferred from the monthly record to the yearly summary sheet, and the total production determined for the year. Birds to be used in the breeding pen are selected largely on the basis of their health, body size, and egg production records, as shown on the summary sheet.

The breeding-pen record. The records of the females used in the breeding pen are obtained from the yearly summary sheet and recorded on the breeding-pen record. The record of the male used in the breeding pen is obtained from the pedigree index record.

The females used in the breeding pen are trap-nested. The pen number, the leg-band number of the hen, and the date are marked on the large end of the hatching egg at the time the hen is released from the nest, and the record made on the monthly egg record sheet.

The incubation and chick-banding report. The male's record and the hen leg-band numbers are taken from the breeding-pen record and recorded on the incubation and chick-banding report. A separate sheet is used for each breeding pen.

It is a good plan to separate the hatching eggs by pen numbers at the time they are gathered and by hen numbers in the pen at the time they are set (Fig. 4–25). The number of eggs set from each hen is recorded at the time they are set and each hen's eggs are set together in the tray. Sometime between the sixteenth and eighteenth day of incubation, the eggs should be candled, the infertile eggs recorded, the dead embryos and infertile eggs re-



U. S. D. A

Fig. 4–25. A convenient cabinet for holding hatching eggs until placed in the incubator. The top of the cabinet has indentations so that eggs may be arranged according to the hen or the pen they come from. The two rows of drawers are for holding the eggs from different pens.

moved, and each hen's hatchable eggs placed in a separate pedigree basket or sack for hatching.

At hatching time each hen's chicks are counted, wing-banded (Figs. 4–26 and 27), and the numbers recorded on the incubation and chick-banding report.

The pedigree record. The wing band, pen and dam's numbers are taken from the incubation and chick-banding report and recorded on the pedigree record. The wing-band numbers are listed in numerical order. Spaces are provided for recording the date, season, and sex of every chick removed and for the sex and leg-band number of each bird kept.

The pedigree record should be kept in the brooder house and each bird recorded at the time of removal. Some breeders go over all of the chicks when six or eight weeks old and again at twelve or sixteen weeks, as well as at the time of housing (Fig. 4–28), and cull out and record any slow-growing, poorly feathered, or otherwise abnormal birds.

The female summary record. The breeding pen progeny record (Fig. 4–29) is the most important of all the records kept. It shows whether or not birds used in the breeding pen are able to transmit desirable characters to their offspring.

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Fig. 4-26. Pedigreeing chicks. Each hen's eggs are hatched in a separate basket or compartment. Each chick is wing banded and the wing-band number recorded on the incubation and chick-banding report.

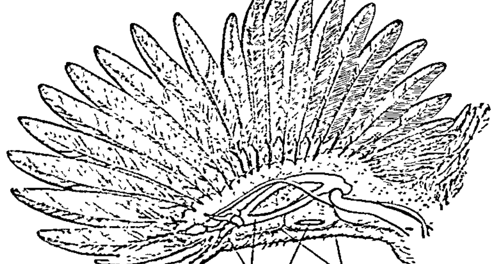

Fig 4-27 Structure of the wing, showing location of the wing band. (Cornell Extension Bulletin 117)

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Fig. 4–28. Inspecting U. S. R. O. P. cockerels. Those approved for breeders will be leg banded and pedigrees approved by the inspector.

THE NATIONAL POULTRY IMPROVEMENT PLAN
U. S. R. O. P. PEDIGREE RECORD
(For breeders who use serially numbered wing bands)

Name ________ Breed and variety ________ Date of hatch ________

Chick Wing-Band No.	Pen No.	Dam's No.	Sex	Sex-Linked Feathering	At ___ Weeks		Breast Breadth	Keel Length	Remarks (U. S. R. O. P. Leg Band No., defects, disposal, etc.)
					Feathering	Body Weight			
1									
2									
3									
4									
5									
6									
7									
8									
9									

Fig. 4–29. U. S. R. O. P. pedigree record.

The records of the male and dams may be copied from the breeding-pen and incubation and chick-banding record sheets. Most of the large poultry breeders place the records on IBM cards.

The records of the female progeny may be obtained from the pedigree record and from the pullet year summary sheet. A portion of a typical pedigree record is shown above.

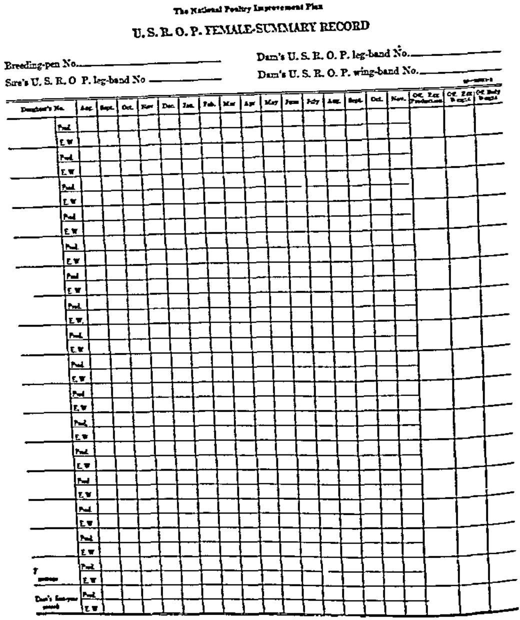

Fig. 4–30. U. S. R. O. P. Female-Summary Record.

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Chapter 5

Incubation

INCUBATION PRACTICES may be better understood if the principles underlying them are more thoroughly explained. Those who investigate the factors influencing hatchability should have some knowledge of the structural and physiological development of the chick embryo. Those who operate the incubators should be able to do a better job if they understand the development of a baby chick.

Development of the Chick Embryo

The development of the chick embryo is a very interesting phenomenon. Embryologists are interested in its early development because of the general information about embryology which may be obtained by studying the early stages of development of the chick embryo, these stages being quite similar to those of the mammals. The poultryman is interested in the embryology of the chick because an understanding of its development will supply information as to the requirements for incubation, and will point the way to better incubation practices. In twenty-one days remarkable changes occur inside the egg. During this time a mass of nutritive material is transformed into a complex living organism.

In discussing the development of the embryo it is well to consider the anatomical or structural development as well as the physiological development which the embryo undergoes from fertilization to hatching.

Anatomical Development

The development which takes place in an egg from the time of fertilization to the time of hatching is one of the wonders of nature which man has revealed to himself by the use of the microscope. The complexity of this development cannot be understood without some thorough training in embryology.

Development before the egg is laid. Soon after fertilization, cell division begins. It continues as long as the temperature of the egg is above 82° F. and, after hatching, until growth has been completed. As cell division progresses the blastoderm spreads out over the yolk. The cells are first arranged in a single layer (the ectoderm) but they soon form, by invagination or folding under, another layer—the entoderm. The formation of the entoderm is called gastrulation (Fig. 5–1).

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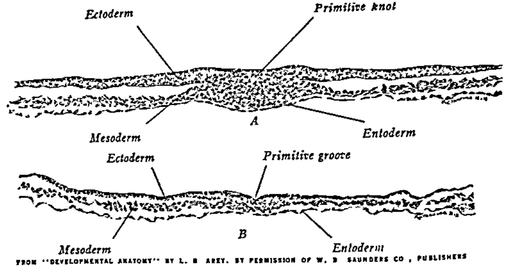


FROM "DEVELOPMENTAL ANATOMY" BY L. B. AREY. BY PERMISSION OF W. B. SAUNDERS CO., PUBLISHERS

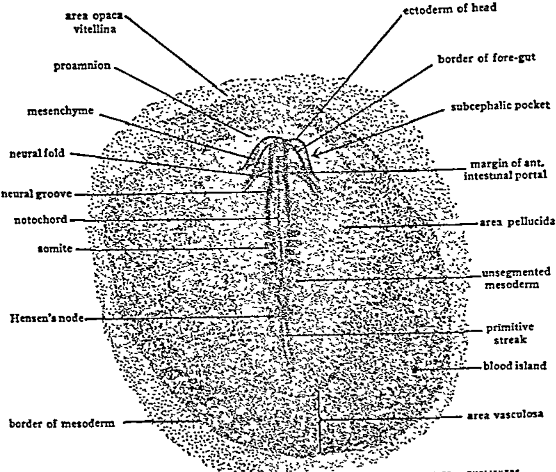
Fig. 5–1. Transverse sections of a chick embryo at the stage of the primitive streak, showing the primary germ layers: A, through the primitive knot; B, through the primitive groove.

Parthenogenesis. Olsen of the U. S. D. A. Research Service has established that in both turkeys and chickens, parthenogenesis (spontaneous development of embryonic tissue) may occur in eggs produced by nonmated females. Olsen was able to hatch a few of these eggs and to raise some to maturity. One of the males was reported to have sired poults.

Development during incubation. After the fertile egg is laid, embryonic development proceeds when the egg is held where the temperature is higher than 82° F. The two primary germ layers (ectoderm and entoderm) are usually formed by the time the egg is laid, and the third layer (mesoderm) is formed soon thereafter if a suitable incubation temperature is maintained. From these three primary germ layers the different parts of the embryo develop. The skin, feathers, beak, claws, nervous system, and the linings of the mouth and vent develop from the ectoderm. The entoderm gives rise to the respiratory and secretory organs and the linings of the digestive tract. The bones, muscles, blood, excretory and reproductive organs have their origin in the mesoderm.

First day. The primitive streak is visible after about sixteen hours of incubation in the incubator. Thereafter development proceeds rapidly, many new organs arising between the sixteenth and twenty-fourth hours of incubation. The head of the embryo becomes differentiated; the foregut is formed; four somites are visible; the blood islands, which later develop into a blood system, appear in the area vasculosa; the neural fold arises which later forms the neural groove; and the coelom and the pericardial regions make their appearance.

Second day. The neural fold closes, forming the neural groove, the anterior part of which develops during the second day into the different parts of the brain. the forebrain, midbrain, and hindbrain. The heart is formed during this period and by the forty-fourth hour of incubation has begun to beat. Two distinct circulatory systems are established, one within the body of



FROM "EMBRYOLOGY OF THE CHICK" BY B. M. PATTEN BY PERMISSION OF THE BLAKISTON CO., PUBLISHERS

Fig. 5–2. A chicken embryo showing 24 hours' development.

the embryo and the other, the vitelline circulation, extending out from the heart into the egg. The eye and the auditory pits of the ear begin to develop.

The extra-embryonic membranes (Fig. 5–3), the yolk sac, amnion, allantois, and serosa begin developing during the second day. The yolk sac will later envelop the entire yolk which serves as a source of food material for the embryo and the newly hatched chick. A considerable portion of the yolk remains to be taken into the body cavity of the chick shortly before hatching.

The amnion is formed during the second and third days of incubation. The amniotic fluid fills this cavity and surrounds the embryo also enclosed in the amnion. The embryo is thereby protected from shocks and possibly adhesions. The serosa, which is formed at the time the amnion is formed, surrounds the other extra-embryonic membranes, lies next to the shell membranes, and later fuses with the allantois.

Structure of the four-day-old chick embryo. By the end of the fourth day of incubation the embryo has all of the organs needed for its development and most of the parts of the chick can be identified. However, the embryo cannot be distinguished from that of mammals. The allantois appears during the third day of incubation as an evagination of the hind-gut. The allantois later surrounds the entire egg contents and fuses with the serosa to form the chorion. The capillaries of the allantois therefore come in contact with the

shell membrane. The allantois serves as a respiratory and also as an excretory organ for the embryo. The allantois circulation is also a medium by which nutrients from the albumen and calcium from the shell are carried to the embryo.

The leg and wing appendages are now visible as limb buds. The tail has made its appearance. Five divisions of the brain can be located. The spinal nerve roots have begun their development. The lens of the eye, the auditory vesicles, and the olfactory pits are visible. The heart has not been enclosed inside the body and can be observed to beat if the egg is opened. The other internal organs have already begun their development.

The embryologist is not interested in the development of the chick embryo beyond the fourth day because from there on only growth takes place. For him the important story is ended, but the poultryman continues to be interested because his objective in incubation is a well-hatched chick and he needs to know more about the development which occurs throughout the entire period of incubation.

Later embryo development. By the sixth day the main divisions of the wings and legs are visible. The feather tracts appear on the eighth day and by the ninth day the embryo has a birdlike appearance. On the thirteenth day the color of the chick down may be observed. By the sixteenth day the beak, nails, and scales are well formed. The supply of albumen is now about exhausted and therefore the yolk serves as the sole source of nutrients.

Hatching. On the seventeenth day the fluid in the amnion begins to decrease. The yolk is drawn into the body cavity on the nineteenth day. The beak soon thereafter pierces the air cell and pulmonary respiration begins. The normal position of the chick for hatching is with the head under the right wing, in the large end of egg, and the legs drawn up towards the head. Two special mechanisms, the horny cap on the upper mandible and muscles on the back of the neck, are developed for hatching the chick. The horny cap serves as an instrument for pipping the shell and the enlarged muscles on the neck supply the power for pipping. The allantois, having served its function as a respiratory and excretory organ during embryological development, is no longer needed and appears in the shell at hatching as a dried up membrane filled with blood vessels.

Critical stages in incubation. There are definite stages in the development of the chick embryo when mortality is highest. These stages occur in chickens during the first and third weeks. Bronkhorst has determined the daily distribution of embryonic mortality in high and low hatching lines (Fig. 5–4). A satisfactory explanation of the critical stages has not been given, but it will probably be found in the physiological changes which occur in these embryos during the first and third weeks. Much of the mortality which occurs at the end of the incubation period can be attributed to abnormal embryo positions which are caused by inheritance as well as environmental factors and feeding The early embryonic mortality may arise from the efforts of the embryo to shift its source of energy from a simple compound (glucose) to a more complex substance (protein), which requires deamination.

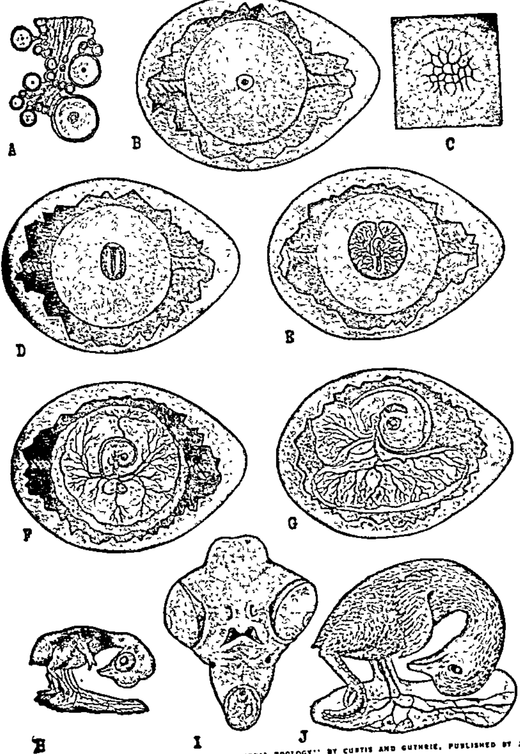


Fig. 5–3. The development of the chick. A, Part of the ovary showing ova in different stages of development. B, The fertilized egg at time of laying. C, Early cleavage of the blastoderm. D, Egg opened to show the late neural-fold stage and extension of blastoderm over yolk. E and F, Stages during which the circulation is becoming established as the blastoderm extends further over the yolk. The allantois appears as a bladder-like outgrowth at the posterior end of the embryo in F. G, Stage in which the allantois has enlarged and the yolk, surrounded by the yolk sac, has become reduced. In F and G the amnion is shown closely surrounding the embryo. H, Later stage showing yolk stalk. I, Front view of head, showing eyes, nasal openings, mouth, and ears. J, A stage shortly before hatching, showing yolk stalk and remains of yolk.

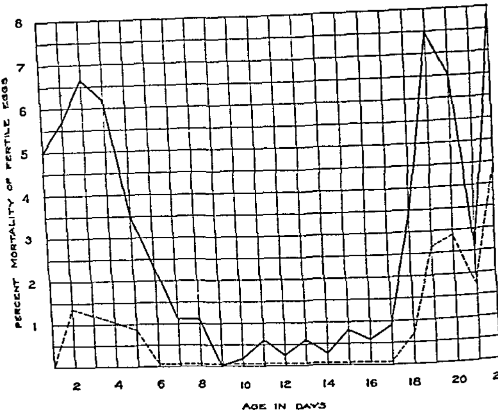


Fig 5-4. Daily embryonic mortality, in per cent of fertile eggs, within a high and a low (---) hatching line of White Leghorns. (From Bronkhorst.)

Physiological Development of the Chick Embryo

The poultryman, as well as the physiologist, is interested in the physiology of the embryo and the physiological changes which occur during incubation. A more thorough understanding of these phenomena may help solve some of the problems of incubation.

General metabolism of the embryo. Under the heading of general metabolism, pH changes and water metabolism may be considered. The hydrogen concentration of unincubated eggs remains fairly constant, but when fertile eggs are incubated, the pH changes considerably. Before incubation, the yolks have a pH of 4.5 and the whites a pH of 8.3. During incubation, the pH of the yolks rises steadily to a pH of 6 about the tenth day and neutrality (pH7) by the sixteenth day. The pH of the white decreases regularly to neutrality on the tenth day and a pH of 6 on the fifteenth day of incubation. The allantoic liquid remains nearly neutral and the amniotic fluid remains neutral until the eleventh day, after which it becomes decidedly acid in reaction.

The relative water content of chick embryos decreases from about 94 per cent on the fifth day to about 80 per cent at hatching time. The egg of the domestic fowl loses water by evaporation at a constant rate (about 5 per cent weekly) during the process of incubation, the rate being governed by the rel-

ative humidity of the atmosphere of the incubator and the physical characteristics of the egg. Air exchange (ventilation) in the incubator is restricted to near the minimum amount required in order to aid in the maintenance of a desirable humidity in the machine.

The egg shell is porous to permit the entrance of oxygen for embryo respiration and the escape of carbon-dioxide, a by-product of embryo metabolism. Eggs with thin, porous shells permit the escape of too much moisture resulting in poor hatches and small, nervous chicks. When hatched under excessive humidity, the chicks are heavy, soggy, and lack vigor.

During the first ten days water passes from the white into the yolk, the water content of the white decreasing and that of the yolk increasing. From the tenth day until hatching the yolk loses water, and by the twenty-first day the water content is about the same as that of the yolk of a fresh-laid egg.

Energy for embryo development. Eggs are a good source of energy; however, they are usually too expensive for human consumption, primarily as a source of energy content. The energy is concentrated mainly in the yolk because of its high fat and relatively low moisture content. There is some energy in the albumen of the egg. Energy value of eggs varies widely depending on size.

During embryo development, the energy content of the egg decreases because heat is produced by the developing embryo, a small amount the first few days with a gradual increase as the embryo increases in size. Large incubators have to be equipped with cooling devices for summer incubation because the temperature of the intake air used for ventilation plus the heat (energy) produced by the incubating eggs raise the incubator temperature above 100° F. This may result in high embryo mortality.

The sources of energy for the developing embryo are in the order of their usage, carbohydrates, proteins and fats. Needham says:

> It is possible that carbohydrate is first combusted because it requires no preparation. Proteins must be deaminated, fats must be desaturated, and probably the embryo in its earlier stages cannot do either of these things, but, on the other hand, glucose lies ready for use, and it is significant that what is combusted is free, not combined, carbohydrate. There is already evidence that the power of desaturation of fats only arises at the comparatively late stage of development, e.g., the tenth to the fifteenth day in the chick. And we may look on the unsaturated fatty acids which are notably present in the yolk as a preparation for these conditions.

Carbohydrate metabolism. Though the egg contains only a small amount of carbohydrate material and this is used throughout the incubation period, it is the chief source of energy during the early development of the embryo. The carbohydrates found in the chick embryo during the early stages are very largely glucose in combination with protein. During the first week glycogen increases outside the embryo and free sugar increases within the embryo. During the second week the free glucose continues to increase and the glycogen of the yolk sac increases. Between the seventh and eleventh days

some fat is transformed into carbohydrates by the embryo. By the tenth day the pancreas is secreting insulin. Beginning at about the eleventh day the liver is able to store glycogen.

Fat metabolism. Fat is not utilized by the embryo until after the fifth day of incubation and it is not deposited in the embryo until after the tenth day. Fat serves as an important source of energy for the embryo, particularly during the later stages of development when most energy is needed. About 99½ per cent of the fat of the egg is contained in the egg yolk. About one-third of the fat of the egg is lost by combustion and the other two-thirds is transferred to the embryo.

Protein metabolism. The proteins of the embryo are derived from the proteins of the egg. A number of investigators have shown the decrease of the different amino acids in the egg white and yolk during incubation and the increase of these amino acids in the embryo as it develops. The amino acids essential for embryonic development must be present in the white and yolk of the egg. Those which have been identified are tryptophane, tyrosine, histidine, arginine, lysine, and cystine.

The percentage of nitrogen excreted by the chick embryo in different forms are ammonia 1 per cent, urea 7.6 per cent, and uric acid 91.4 per cent. During the first week the nitrogen is excreted principally as ammonia and urea, but after the first week it is excreted almost entirely as uric acid, which is the form in which the adult bird excretes nitrogen.

Mineral metabolism. A number of investigators have worked on calcium metabolism in the hen's egg during the process of incubation. It has been shown that in fertile eggs which are incubated the shell loses calcium and that the calcium content of the interior of the egg increases. This change occurs only when an embryo is developing in the egg. More calcium is transferred from the shell to the embryo when the relative humidity is high than when it is low. The transfer of calcium from the shell to the embryo is also influenced by the amount of vitamin D present in the egg.

Phosphorus is an important constituent of the embryo. Most of the metabolism of phosphorus occurs after the fifteenth day of incubation and is associated with bone formation.

The sodium, potassium, and chlorine content of the white decrease throughout the incubation period, while the quantity of these elements present in the embryo increases steadily. In the yolk these elements increase until the seventh day and then decrease, thus indicating a greater movement of these elements from the white to the yolk during the first week than from the yolk to the embryo. All minerals needed by the chick embryo are obtained from the egg.

Enzymes in embryonic development. Enzymes play an important part in the development of the chick embryo, reducing substances of the egg to less complex structures so that they may be utilized by the developing embryo Some are present in the egg and others are secreted by the embryo.

Table 5–1

PERCENTAGE INFERTILITY AND PERCENTAGE HATCHABILITY OF VARIOUS TYPES OF DEFECTIVE EGGS [1]

Type of Defective Eggs	* Number of Eggs Set	* Percentage of Total Eggs Examined	Infertile Eggs	Percentage of Eggs Infertile	Number of Chicks Hatched	Percentage Hatch	
						Fertile Eggs Set	Total Eggs Set
Cracked eggs	610	1.27	155	25.4	242	53.2	39.7
Extra large eggs (65 gr. or more)	332	.69	113	34.0	155	70.8	46.7
Small eggs (45 gr. or less)	155	.32	80	51.6	60	80.0	38.7
Misshapen eggs	68	.14	21	30.9	23	48.9	33.8
Poor shells	102	.21	28	27.5	35	47.3	34.3
Loose air cells	47	.10	13	27.7	11	32.4	23.4
Misplaced air cells	406	.85	89	21.9	216	68.1	53.2
Large blood spots	174	.36	37	21.3	98	71.5	56.3
All defective eggs	1,894	3.95	536	28.3	840	61.8	44.4
Control eggs	3,031		537	17.7	2,174	87.2	71.7

* The first two columns of figures in Table give the numbers and percentages of eggs of various types found among 47,950 newly laid White Leghorn eggs.
[1] Olsen and Haynes, 1949.

Hormones in chick development. Very little is definitely known about the function of hormones in the development of the chick embryo. Most of the hormones are not present in the freshly laid egg but are found after the endocrine glands develop to a stage where they are capable of secreting them. Insulin and the estrogenic hormone are present in the yolk of the freshly laid egg. This yolk insulin may play an important part in carbohydrate metabolism before the insulin-secreting cells of the pancreas become functional. After the eleventh day the embryo is capable of insulin secretion. Adrenalin, which is secreted by the adrenal glands, is first formed in the embryo on the eighth day of incubation.

Pigment metabolism. The fresh egg contains only a few pigments but the chick contains several that are unlike those of the fresh egg. The embryo during its development is capable of synthesizing hemoglobin, bile pigments from the breakdown of hemoglobin, the carotenoid pigments (red and greenish yellow), and the melanin pigments of the dark-colored chicks.

Vitamin production by the embryo. Fresh eggs laid by hens properly fed for the production of hatching eggs contain all of the vitamins essential for hatching. Unless these vitamins are provided by nutrition of the breeding stock the embryo could not develop and hatch. Some of the vitamins, however, are synthesized by the embryo.

Factors Influencing the Hatchability of Eggs

Many factors or conditions affect hatchability, some of which are known and others still unknown but may be revealed by later research.

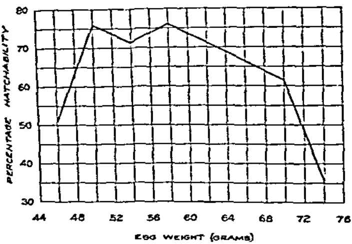


Fig. 5–5. Relationship between percentage hatchability and average egg weight per bird, based on the records of 367 hens and for one hatching season. (From Godfrey.)

Hatchability is of vital concern to the hatcheryman because it directly affects his profits and may be the difference between profit and loss in the business. Many hatcheries could increase their hatches by 5 per cent or more by applying the information on fertility and hatchability available at present.

The discovery of a method or process whereby fertility or hatchability of eggs set in the United States would be increased by 2 per cent, would result in extra chicks valued at approximately $6,000,000 annually. Approximately 30 per cent of all eggs set in the United States fail to produce chicks.

The poultryman is interested in the number of saleable chicks he can hatch out of the eggs purchased and that depends upon two general conditions—the fertility of the eggs and the hatchability of the fertile eggs.

Fertility

It is estimated that 10 per cent or more of the eggs set in the United States each year are infertile. Such eggs are not only a loss to the industry but they occupy valuable incubator space and require time-consuming labor in handling.

Some eggs laid within 24 hours after mating may be fertile, but generally, within two weeks after a flock is mated, satisfactory fertility may be attained. The removal of males from a flock is followed by a decline in fertility within one week for chickens and two weeks for turkeys. Few, if any, fertile eggs will be produced in chickens after three weeks and in turkeys after six weeks. If the males in a mating are changed, the eggs laid within a few days are fertilized by the new males and there is little overlapping in progeny.

Sperm. Sperm showing most motility after production give the highest fertility. Semen containing a high percentage of abnormal sperm have lower fertility than more normal sperm. Sperm production of spring hatched males increases during the winter and early spring and declines in the late spring and summer.

The amount of light received by the bird influences sperm production. The minimum amount of light required for normal production is about 12 hours daily.

Rations. Sperm production may be reduced by deficient or restricted rations. Prolonged deficiency of vitamin E may result in sterility in some males. Both the sperm production and fertilizing capacity of cockerels may be affected adversely by restricted feed consumption which results in loss of body weight. Adequate nutrition of the breeding stock is essential to fertility.

Hormones. The science of endocrinology has yielded valuable information about fertility in poultry. The removal of the pituitary gland causes atrophy (shrinkage) of the testes and cessation of sperm production. Males injected with pituitary extract and pregnant mare's serum produced more sperm than untreated controls. Injections of male sex hormone have increased fertility. Thiouracil, which reduces thyroid activity, also reduces the fertilizing capacity of sperm. The injection of adrenalin depresses sperm production.

Age. Fertility in both males and females is at a maximum during the first year and generally declines thereafter with age. Though fertile eggs may be produced by hens mated with cockerels ten weeks of age, satisfactory fertility is not attained until the males are about six months old.

Egg production. Females of high egg production tend to produce a higher percentage of fertile eggs than those laid by birds who do not produce as many eggs.

Preferential mating. The fertility of eggs laid by some hens in individual male matings may be increased by changing males. Possibly both males and females have their preferences. Some hens, completely sterile when mated with one male, lay highly fertile eggs when another male is used. The "peck order" that exists in fowl no doubt affects mating and fertility.

Breeding. The fact that fertility varies with strains and breeds indicates some degree of inheritance of this trait, though of a low order.

Work at the California Station indicates that fertility and hatchability are independent in inheritance. Inbreeding tends to lower fertility.

Hatchability

Both research workers and hatcherymen have observed that hatchability is an inherited trait. Too often, poor hatching flocks are being retained as hatchery-supply flocks when they should be completely replaced by stock possessing the potential to hatch well. In building a flock program, the hatcheryman should select strains that possess high fertility and hatchability in so far as he can obtain such stock.

Inbreeding. Close inbreeding, without rigid selection for hatchability, has been shown to be detrimental to hatchability in both chickens (p. 89) and turkeys.

Crossbreeding and incrossbreeding. Though the results of crossing pure breeds or incross breeds will depend upon the characters or genes carried by the parent stock, such crossing usually results in increased hatchability (p. 90).

Lethal and semilethal genes. Geneticists are discovering genes in poultry

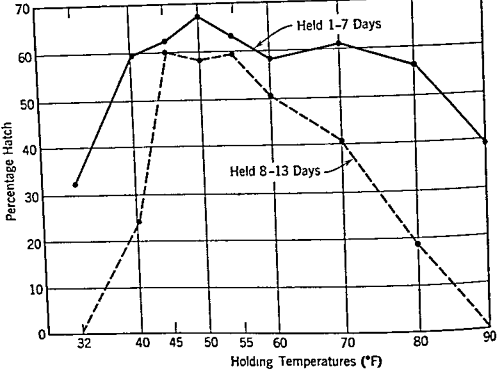


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Fig. 5–6. Relation of holding temperature to hatchability of New Hampshire eggs.

Table 5–2

EFFECT OF AGE OF EGG AND HOLDING TEMPERATURE ON THE PERCENTAGE HATCH OF ALL EGGS SET (NEW HAMPSHIRES)

Days Held	40° F.		50° F.		55° F.		60° F.		70° F.		89° F.	
	Eggs Set *	Per Cent Hatch all Eggs	Eggs Set	Per Cent Hatch all Eggs	Eggs Set	Per Cent Hatch all Eggs	Eggs Set	Per Cent Hatch all Eggs	Eggs Set	Per Cent Hatch all Eggs	Eggs Set	Per Cent Hatch all Eggs
1	89	69.7	106	70.8	104	64.4	103	59.2	104	59.6	106	68.8
2	98	70.4	113	66.4	108	63.9	108	63.0	109	60.6	108	62.0
3	91	64.8	107	68.2	106	67.0	109	61.5	111	64.9	113	64.6
4	90	65.6	105	68.6	107	67.3	104	56.7	108	62.0	107	57.9
5	95	50.5	104	64.4	110	60.0	106	58.5	105	54.3	107	50.5
6	92	51.1	108	69.4	107	59.8	109	56.0	107	66.4	109	50.5
7	92	41.3	108	67.6	108	60.2	108	62.0	111	59.5	108	44.4
8	93	36.6	104	61.4	105	63.8	100	59.0	100	50.0	101	37.6
9	96	24.0	117	65.0	117	59.0	108	57.4	118	47.5	120	26.7
10	90	40.0	106	52.8	107	57.9	113	49.6	104	36.5	106	25.5
11	92	18.5	110	57.3	114	62.3	117	47.0	116	38.8	117	12.8
12	95	21.1	115	53.9	108	55.6	110	44.5	113	36.3	113	7.1
13	88	6.8	106	66.0	110	60.9	104	47.1	110	32.7	109	.9
TOTAL	1193	43.4	1419	66.3	1413	61.0	1399	55.5	1416	50.2	1424	39.4

Table 5–3

RELATION OF SHELL TEXTURE AND HATCHING RESULTS [1]

Trial	Shell Texture	Eggs Set	Percentage Hatch	
			All Eggs	*Fertile Eggs*
I	Good	1011	54.8	67.1
	Poor	336	60.0	72.2
II	Good	1797	59.0	76.3
	Poor	925	57.1	77.4

[1] Mo. Agr. Expt. Sta. Bul. 341.

(both chickens and turkeys) that cause the death of embryos and thereby lower hatchability. They have reported nineteen lethal genes in chickens and three in turkeys. The effects of some of these genes (p. 78), result from abnormalities which prevent hatching, such as deformed beaks.

Egg production. Eggs laid by hens producing at a high rate are not only more fertile, but they possess higher hatchability than eggs laid by less productive layers.

Age. Hatchability tends to be highest during the first laying year for both turkeys and chickens.

Management of Flocks

Hatchability is affected by the management of the breeding stock in mating, housing conditions, range, and feeding.

Matings. The ratio of males to females affects fertility; too few or too many males may be used for best results. The Oregon Station has shown that 5 to 6 Leghorn or Cornish males per 100 females and 6 to 7 New Hampshire males per 100 females are sufficient for maximum results.

Housing conditions. There is evidence that both extremely cold or hot weather tends to reduce hatchability as well as fertility. Therefore, it is advisable to cope with these extremes through a suitable housing program. If freezing conditions in the house can be avoided in winter, the flock as well as the caretaker will benefit. If temperatures do not rise above 85° F. in the houses during summer, hatchability is not likely to be reduced.

Feeding. The fertile bird's egg is a complete reproductive unit, containing all nutrients necessary for the development and hatching of its young. Everything contained in the egg except the sperm is deposited in the egg by the hen. The nutrients needed by the hen to produce a satisfactory hatching egg must, of course, be in the rations the hen consumes. Breeder mashes, especially fortified with vitamins necessary for hatchability, should be fed the breeding flock (p. 277).

It should be observed that an adequate and well-fortified ration is necessary for satisfactory hatchability because the vigor of the chicks and their early livability and performance depend upon the vitamins and other nutrients they have stored before hatching.

Selection of Hatching Eggs

Certain physical characteristics of eggs are related to hatchability, and by eliminating eggs that have characters associated with poor hatchability, hatching results can be improved. It is also true that these characteristics are inherited and may be bred into poultry by continued selection. The more common characters are size, shape, color, shell quality, and interior quality.

Size of egg. The size of the egg is related to hatchability (Fig. 5–5). A similar relationship exists in turkey eggs. Extremely large and very small eggs do not hatch well. It is fortunate that the best chicken eggs for market (23–28 ounces per dozen) also possess high hatchability.

Shape of egg. Eggs that deviate considerably from normal do not hatch well. However, eggs that are only slightly off shape, ridged, or wrinkled, appear to hatch as well as eggs shaped perfectly. Table 5–1 shows that eggs definitely misshapen hatched only 33.8 per cent as compared to 71.1 per cent for normal eggs. It should also be noted that the shape of an egg is inherited and can be established by breeding.

Shell. The quality of the shell is related to hatchability. Eggs possessing strong shells hatch best while eggs with thin shells generally do not hatch well (Table 5–3). The kind of shell deposited on the egg depends upon breeding, nutrition, and weather. Some strains or families possess the ability to produce eggs with thick, strong shells whereas others lay eggs with thin, weak shells. The amount of calcium and vitamin D in the ration affects the shell. Eggs produced in hot weather have thinner shells than those produced when the weather is cold. Attempts to candle eggs for shell texture and to relate such appearance may be misleading, because the mottled appearance of an egg before a candle might be interpreted as poor shell texture, when it is actually due to the moisture in the shell.

Interior quality as observed by candling. Eggs that show poor market quality by candling do not hatch well. Table 5–1 shows that eggs with loose air cells hatched only 23.4 per cent as compared to 71.7 per cent for normal eggs. It will also be noted that in this same experiment the percentage of eggs hatched containing large blood spots was 56.3 per cent or 15.4 per cent below the controls.

There is also evidence that eggs which show high quality when candled before incubation, i.e., show movement of yolks and well-centered position of the yolks, hatch 10 to 15 per cent more chicks than eggs showing a weak or lower quality condition.

Care of Hatching Eggs

The hatchability of the best eggs can be destroyed after the eggs are laid and before they are set by improper care during the holding period. The important conditions during this period are proper temperature, handling, humidity, age of egg, and cleanliness of shell.

Temperature. Hatching eggs which are held in too hot or cold an en-

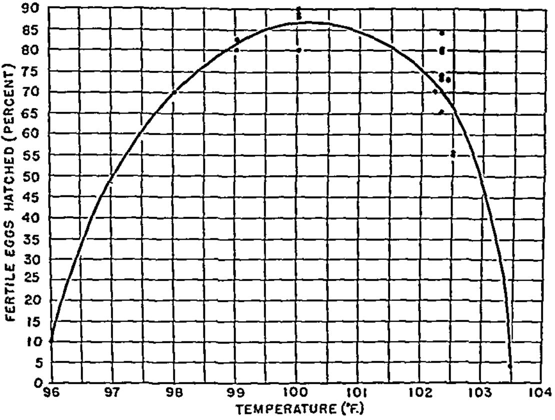


Fig. 5–7. Effect of temperature of incubation on percentage of fertile eggs hatched—relative humidity 60 per cent, oxygen 21 per cent, carbon dioxide below 0.5 per cent. (Barott, 1937.)

vironment may yield poor hatches, and in extreme cases the hatching power of the egg may be destroyed. The relationship of holding temperatures to the hatchability of chicken eggs is shown in Figure 5–6. The ideal temperature is 50–55° F. Eggs held at zero (air temperature surrounding the egg at 0° F.) lose most of their hatching power within three or four hours. Therefore, it is most important that hatching eggs be protected in cold weather.

Hot weather may be equally as harmful to hatchability as cold weather. When the temperature surrounding the eggs rises above 82° F., the embryos *develop at a relatively rapid rate but this development is not normal. Many* of these embryos weaken and die before or after being placed in incubators for normal incubation. Work at the Missouri Station proved that the hatchability of eggs held at 90° F. for seven days or longer was completely destroyed. (Fig. 5–6.)

In many cases, a basement or cellar will provide satisfactory conditions for hatching eggs. Where many eggs are held, as in an egg station or in a hatchery, it will be advisable to install refrigeration to provide suitable temperature conditions in hot weather.

The importance of proper temperature for holding hatching eggs cannot be over-emphasized to the flock owner (Table 5–8). The commercial hatchery with supply flocks will do well to work with their flock owners on this problem.

Handling. Hatching eggs should be cased small end down in new or sturdy cases, or flats and fillers and handled carefully. Eggs cased large end

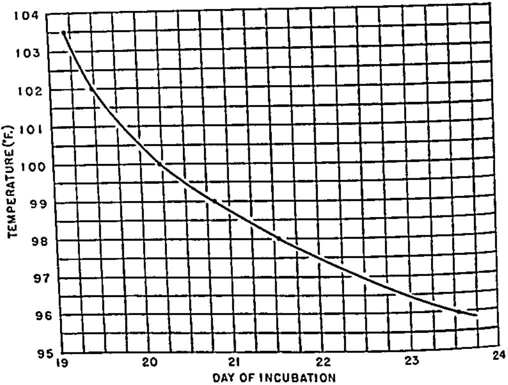


Fig. 5–8. Effect of incubation temperature on the time of hatching chicken eggs. (Barott, 1937.)

down develop more tremulous air cells than eggs cased with pointed ends down. Eggs containing loose air cells hatch very poorly (Table 5–1). Very few eggs are cracked by rough handling of the case. The more rigid tray packs give better protection to hatching eggs than the regular separate filler and flat packs.

Turning. If eggs are held longer than one week, hatching results will be improved by turning The most practical way to do this is to tilt the case shifting the position of the egg. Tests made at the Missouri Station indicated that if eggs were held for seven days or less, hatchability was slightly depressed if the eggs were turned. However, it was observed that eggs held for more than one week (8–13 days) hatched best if they were turned daily from the time of laying.

Humidity. High humidity in a hatchery tends to prevent evaporation and an enlargement of the egg's air cell. This is important in maintaining the market grade of eggs Trials at the Missouri Station proved that high humidity increased hatchability slightly and improved the observed quality of the chicks. These benefits appeared greater during hot weather. The results indicated that high humidity is desirable but that much expense and effort is not justified to gain these benefits.

Age of egg. The length of time an egg can be held without reducing its hatching power depends upon the temperature at which it is held (Table 5–2). Chicken eggs held at 50° F. to 60° F. retain their hatchability for one week, but after that, they gradually decline to sterility in four weeks. There is

Table 5–4

RELATIVE HUMIDITY AS DETERMINED BY DIFFERENCES IN WET BULB AND DRY BULB THERMOMETER READINGS [1]

Dry Bulb Reading (Degrees F.)	Degrees F. Wet Bulb Is Below Dry Bulb Temperature							
	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4
95.0	94	87	81	75	69	64	59	54
96.8	94	87	81	75	70	64	59	54
98.6	94	87	82	76	70	65	60	55
100.4	94	88	82	76	71	66	61	56
102.2	94	88	82	77	71	66	61	57

[1] Adapted from 22nd edition of Hodgman's Handbook of Chemistry and Physics, 1937.

some evidence that eggs set on the day they were laid do not hatch as well as eggs that are 1–4 days old. Hatching eggs should be delivered to the hatchery and set at least once each week for best results.

Cleanliness of shell. Clean eggs hatch better than soiled eggs. Eggs which have a large part of their surface covered with broken egg material or any other substance that seals the shell will not hatch. Such soilage closes the pores of the shell and interferes with the normal movement of air through the shell to the embryo. Soilage is especially harmful if the air cell (large end) of the egg is covered.

Soiled chicken or turkey hatching eggs are often quite valuable. Dry cleaning may be attempted but this requires considerable labor. Soiled hatching eggs can be washed in warm water containing a disinfectant and the hatchability of such eggs is then restored to normal. However, if the organism that causes hatching eggs to explode is present, serious trouble may be experienced.

Requirements for Incubation

Four environmental conditions are necessary for successful incubation: proper temperature, adequate ventilation for respiration, sufficient humidity, and correct position of the eggs. For best results each of these conditions must be controlled and kept within definite limits. The sciences of physics and engineering have developed modern incubators which make possible intelligent control of the environment of the egg during incubation.

The National Agricultural Research Center has investigated the temperature requirements for eggs incubated in machines where the relative humidity was 60 per cent, the concentration of oxygen 21 per cent, the concentration of carbon dioxide less than 0.5 per cent, and air movement 12 cm. per minute. Under these conditions it was found that a temperature of 100° F. gave the best hatchability. That the temperature requirements are not the same throughout the incubation period is indicated by work reported by Cornell University in 1936, which showed that by lowering the temperature as much as 3° C., during the last few days of incubation, hatchability was increased and the quality of the chicks was improved.

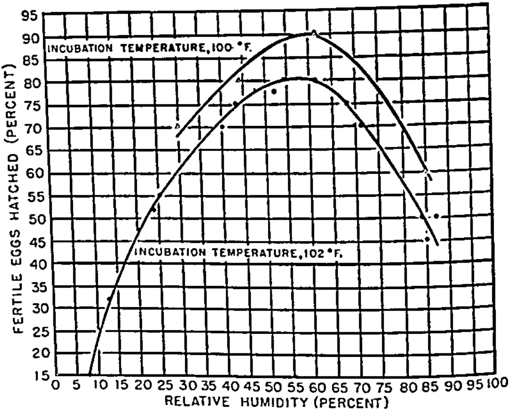


Fig. 5–9. Effect of relative humidity during incubation on hatchability, oxygen 21 per cent and carbon dioxide below 0.5 per cent. (Barott, 1937.)

Both high and low temperatures result in abnormal development and reduced hatchability. High temperatures at first accelerate but later retard the rate of growth and the CO_2 output, while low temperatures retard growth and reduce the output of CO_2. Low temperatures cause an early mortality peak, while both high and low temperatures cause heavy mortality on the nineteenth and twentieth days of incubation. The total length of the incubation period in a forced-draft incubator may be varied from nineteen to twenty-four days by incubating eggs at temperatures from 103.5° F. to 96° F. By incubating eggs in a "still-air" machine at 95° F., hatching may be delayed until the twenty-eighth day. Best hatches are produced, however, when the chicks hatch on the twenty-first day of incubation. In commercial hatchery operation it is desirable that all chicks be out of the incubators by the end of the twenty-first day so that settings may be made on a three-weeks' schedule.

It has been demonstrated by commercial hatcherymen that cooling eggs is not essential for successful hatching when the incubators are properly ventilated and operated at the correct temperature.

The effect of prolonged cooling on the hatchability of eggs is of interest to the hatchery industry because occasionally storms and floods cause electric current interruptions to the hatcheries. The California Agricultural Experiment Station investigated the effect of a twelve-hour electric current interruption on hatching results where the room temperature was approximately

70° F. This station reported that such interruptions (twelve hours) on one day during the incubation period reduced the hatch 3.4 per cent and increased the number of unsalable chicks from 1.8 per cent to 3.4 per cent. These results show that electric current interruptions for several hours do not seriously affect hatching results. During current interruptions the temperature in the top of the incubator may go too high.

Humidity. While humidity in the incubator may vary considerably without reducing hatching results appreciably, there are definite limits and optimum humidity conditions (Fig. 5–9).

The important humidity factor in incubation is the relative humidity of the atmosphere surrounding the eggs. Relative humidity is expressed as the percentage of saturation of the air. A relative humidity reading of 60 per cent means that the air is carrying 60 per cent of the water vapor it is capable of holding at that temperature. The amount of moisture the air can carry varies with the temperature; 1000 cubic feet of air can carry 1.153 pounds of water vapor when the temperature is 70° F., and 2.855 pounds when the temperature is 100° F. Air carrying 1.71 pounds of water vapor per 1000 cubic feet at 100° F. would have a relative humidity of 60 per cent.

The gauge used for determining humidity conditions in the modern incubator is the wet bulb thermometer. The principle involved in estimating moisture conditions from the wet bulb reading is that when the atmosphere is dry evaporation from the wet bulb is increased, and therefore the bulb of the thermometer is cooled to a lower temperature than the dry bulb thermometer records. High wet bulb readings indicate high humidity in the incubator whereas low wet bulb readings indicate dry atmospheric conditions. The relative humidity as indicated by certain differences between dry bulb and wet bulb thermometer readings is given in Table 5–4.

Hatchability of eggs is very definitely affected by moisture conditions.

That there is a definite relationship between humidity and temperature is shown by the work of Townsley. He found that when large forced-draft incubators were operated at 99° F. and wet bulb readings of 75° F., 85° F., and 90° F., the chicks hatched where the humidity was high (90° F. wet bulb reading) came out about twenty-four hours earlier than those hatched where the wet bulb reading was 85° F. The chicks hatched where the humidity was low (wet bulb reading of 75° F.) were twenty-four hours later in hatching than those in the machine where the wet bulb reading was 85° F. The chicks produced where the humidity was high and also where it was low were small and showed "stickiness." It was found that the length of the incubation period could be adjusted to twenty-one days by operating the incubators with the following dry bulb and wet bulb temperatures, respectively: 98° F. and 90° F., 99° F. and 85° F., and 100° F. and 75° F.

Humidity is an important factor in the control of pullorum disease during incubation. Relatively high humidity at hatching time minimizes the circulation of down in the incubator and thereby reduces the spread of pullorum. Fumigation of incubators is more effective when humidity is high.

Most experienced incubator operators try to keep the wet bulb tempera-

	Angle Turned	Eggs Set	Infertile	D1	D2	D3	Chicks Hatched	Per Cent Hatch All Eggs	Per Cent Hatch Fertile Eggs
9-11-52	20°	702	108	12	106	106	370	52.71	62.29
	30°	702	109	17	82	75	419	59.69	70.66
	45°	702	121	16	57	37	471	67.09	81.07
9-18-52	20°	693	82	13	97	97	404	58.30	66.12
	30°	693	81	10	76	53	473	68.25	77.29
	45°	694	71	10	55	30	528	76.08	84.75
10- 2-52	20°	699	76	9	114	88	412	58.94	66.13
	30°	699	83	7	62	54	493	70.53	80.03
	45°	698	66	18	59	25	530	75.93	83.86
10- 9-52	20°	707	58	5	46	67	531	75.11	81.82
	30°	707	56	11	35	40	565	79.92	86.79
	45°	706	42	15	41	23	585	82.86	88.10
G. Total	20°	2801	324	39	363	358	1717	61.30	69.32
	30°	2801	329	45	255	222	1950	69.62	78 88
	45°	2800	300	59	212	115	2114	75.50	84.56

ture about twelve to fourteen degrees below the dry bulb reading during the first eighteen days of incubation and only ten degrees lower than the dry bulb temperature while the chicks are hatching. Reducing the humidity of the incubator or separate hatcher after the hatch is complete strengthens the chicks and improves their appearance when they are removed from the trays and placed in chick boxes.

Ventilation. Since the chick embryo is an animal organism and therefore requires oxygen for its development, adequate ventilation is essential for successful incubation. A normal fertile hen's egg contains all of the materials necessary for embryonic development, except air. The embryo obtains the oxygen necessary for growth from the air which passes through the pores of the eggshell. Closing these pores causes suffocation of the embryo.

Ventilation of incubators is essential for the removal of CO_2 produced by the developing embryos and for supplying fresh air containing a normal quantity of oxygen. Romanoff (1930) showed that when the carbon dioxide content of the air was 1.0 per cent or more and the oxygen was reduced accordingly, the growth of the embryos was slow; and such abnormalities as crooked toes, deformed beaks, and malpositions were common and mortality was high. Meshew found that increasing the oxygen content of the air in incubators at high altitude (5200 to 7200 feet) increased hatchability of both chicken and turkey eggs.

Position of the egg and turning. Best hatching results are obtained when the large end of the egg is uppermost. The Missouri Agricultural Experiment Station reported the following data on the relation of angle of turning eggs to hatching results which justify the following conclusions: (1) The angle

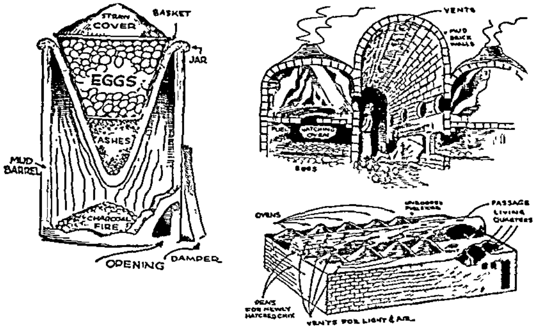


Fig. 5–10. Early incubators. Left: cross section of barrel type Chinese incubator. Right—upper: cross section of an ancient Egyptian incubator. Right—lower: drawing of an Egyptian hatchery. (From "The Baby Chick.")

of turning eggs during incubation affects hatchability very greatly. (2) Turning eggs 30° as compared to 20° increased the percentage of hatch from 61.3 per cent to 69.6 per cent or 8.3 per cent. (3) In three series of experiments, *turning eggs 45° as compared to 30° increased the percentage of* hatch by 5.9 per cent. (4) Turning eggs 40° as compared to 30° increased the percentage of hatch of all eggs by 5.2 per cent and 3.6 per cent in two experiments. (5) *In two series of tests with fresh eggs (1–7 days) turning* eggs 45° as compared to 40° resulted in an increase of 0.5 per cent in one series and 9.2 per cent in the other series. (6) Increased turning improved the percentage of hatch of *all* eggs set for eggs *held* one, two or three weeks.

For normal embryonic development it is necessary to turn or rather shift the position of the egg during incubation, particularly during the first twelve days. Failure to do so results in mortality because the embryos stick to the shell membranes or the yolk adheres to the allantois. The hen turns the eggs under her by shifting her body and by using her beak to shift the position of the eggs. Observers have found that the broody hen may turn her eggs as often as ten times in two hours and at least every hour during the day and night.

A number of investigations have contributed data which show that hatchability is increased by turning up to eight times daily. In commercial hatcheries where forced-draft incubators are used, eggs are not turned but merely shifted in position by tilting the eggs about their short axis. As long as eggs were incubated in incubators where hand turning was required, twice daily was considered sufficient turning; but with the invention of simple egg-turning devices attention was centered upon the extra chicks which could be produced by turning the eggs more frequently.

Natural Incubation

With the eggs of some species natural methods of incubation remain most efficient. However, in the case of the chicken, duck, and turkey, man has perfected artificial methods of incubation which give results superior to those obtained when natural incubation is used.

Artificial Incubation

The art of hatching chickens by artificial methods has been known by man for several thousand years but only within the last fifty years has this method been applied within the industry on a large scale. The economical commercial production of poultry and eggs is dependent upon artificial incubation because the time of hatching can be controlled; the spread of diseases and parasites can be reduced; and the amount of labor required for incubation is reduced.

History. To trace the history of artificial incubation, it is necessary to delve into the early history of the Chinese and Egyptian civilizations. This has been done by a number of writers. The Chinese developed the method as shown in Figure 5–10 in which they heated the eggs with a charcoal fire. The Chinese also used the hot-bed method (decomposition of manure) for heating incubators. The Egyptians constructed large incubators heated by fires built in the rooms where the eggs were incubated. These Egyptian hatcheries were constructed of brick and had a capacity of 90,000 eggs. They were operated on a toll basis, two chicks for each three eggs set being returned to the flock owner. Reaumur in 1750 constructed an incubator and hatched chicks successfully by using fermenting horse manure as a source of heat. It is interesting to note that in southern Australia there is a bird, *Leipoa ocellata,* which incubates its eggs by preparing a nest of vegetable matter in the sand, which later provides by fermentation sufficient heat to incubate its eggs. In 1770 an Englishman, John Champion, hatched chicks by passing hot air through the room where the eggs were located. Bonneman, a French physician, in 1777 hatched chicks by heating a hatching oven with circulating hot water. The first American incubator, a hot water machine, was built in 1844. The first mammoth incubator in America was built by Charles A. Cyphers in 1895. It was a 20,000-egg duck incubator of the room type. Dr. S B. Smith apparently built the first forced-draft incubator, which he patented in 1918 (Fig. 5–12). The Petersime Incubator Company introduced in 1923 the first all-electric incubator. In recent years several new machines have been developed and all makes have been improved (Fig. 5–11).

Management of the Incubator

Proper management of the incubator is essential for the production of chicks. Unless all the requirements for the developing chick embryo are satisfied, poor hatches will result.

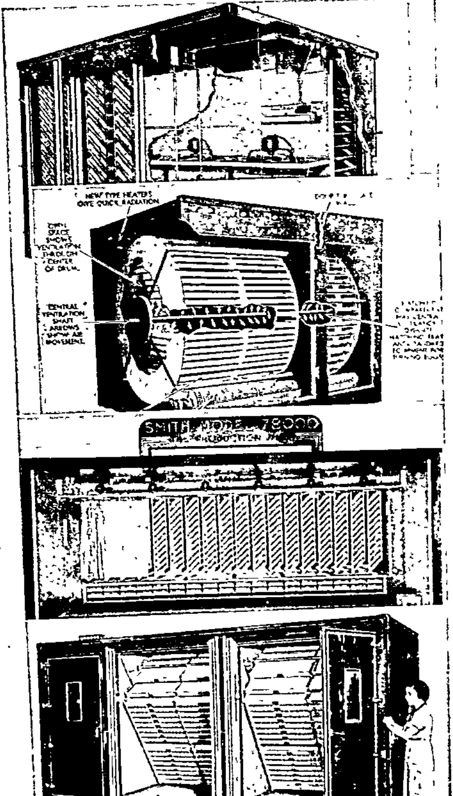


Fig. 5–11. Some forced-draft incubators. From top to bottom: a sectional view of a 24,000-egg Buckeye Incubator (Buckeye Incubator Company); a Petersime incubator with separate hatching compartment (Petersime Incubator Company); a Smith 78,000-egg capacity incubator (Smith Incubator Company); a Robbins incubator with a separate hatching compartment (Robbins Incubator Company).

Fig 5-12 Evolution in modern incubators. Top left, small home incubator. (Courtesy Smith Incubator Company.) Top right, early sectional type incubators. (U. S. D. A.) Center, partial view of hatchery equipped with cabinet type forced-draft incubator for a million egg capacity. (Courtesy Smith Incubator Company.) Bottom, mammoth sectional type incubators. (Ohio Poultry Improvement Association.)

Regulating the temperature. The temperature of an incubator must be controlled within very narrow limits. The instructions of the manufacturer should be followed, keeping in mind the temperature requirements previ-

ously discussed as factors influencing hatching results. All incubators are equipped with temperature-regulating mechanisms which are sensitive to temperature changes inside the incubator. In the electrically heated machines the thermostat makes and breaks the electric circuit and thereby the temperature can usually be kept within very narrow limits. In incubators heated by other sources, a thermostat is used which regulates the amount of heat entering the compartments where the eggs are located.

If, for some reason, the source of heat is cut off for several hours, little damage may be done. In case of such interruptions, the room temperature should be kept up and the heat inside the incubator conserved by closing the ventilators on the machine. Precautions should be taken to prevent the temperature in the top of the incubator from going too high.

Turning the eggs. Turning during the early stages of incubation is necessary for normal embryonic development. Best hatching results are obtained when the eggs are turned at least eight times daily up to the eighteenth day. Mammoth incubators and some small machines are equipped with turning devices which reduce to a minimum the labor required for turning the eggs. Eggs should be turned gently so that the delicate chick embryos will not be injured.

Ventilation. Proper ventilation is essential for incubation so that the embryos will be supplied with air containing an adequate amount of oxygen and less than 1½ per cent of carbon dioxide. The operator of an incubator should bear in mind that the incubator cannot be properly ventilated unless the room in which the machines are located contains fresh air. Therefore the room must be ventilated before any progress can be made in ventilating incubators located in such rooms. The oxygen requirements of chick embryos increase very rapidly as they develop and therefore ventilation must be increased during the later stages of incubation.

Hatchery Management

Although the Egyptians have used commercial hatcheries (Egyptian ovens operated as public institutions on a toll basis for hatching chicks) for centuries, the development of the chick hatchery in America did not occur until the twentieth century.

In 1918 there were 250 chick hatcheries operating in the United States. By 1943 there were 10,112 hatcheries with a total capacity of 504,640,000 eggs. In 1953 the number of hatcheries was reduced to 7,977 but the egg capacity increased to 600,000,000. By 1958, the number was further reduced to 4,939 hatcheries in the United States (Fig. 5–14). However, 2.5 billion chicks were produced that year. The trend is toward fewer hatcheries and toward hatchery chains. More chicks are being produced annually per unit of capacity. Recently some capacity has shifted to the newly developed broiler-producing areas.

Location for a hatchery. The type of chick business (local, mail order, or wholesale) the hatcheryman expects to do will govern somewhat the loca-

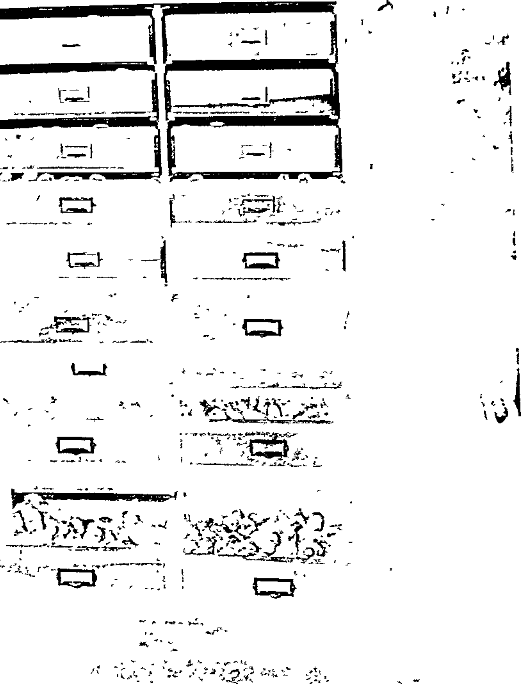
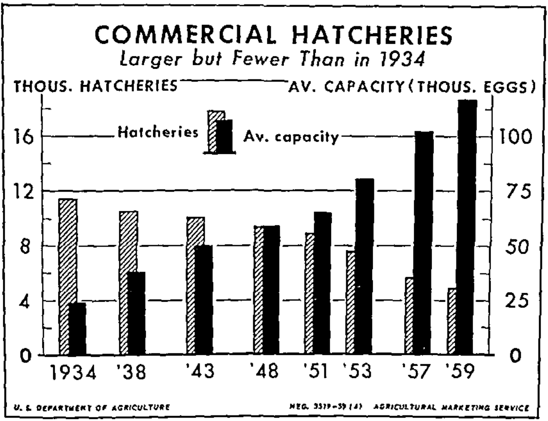


Fig. 5–13. Baby chicks ready to leave a separate hatcher.

tion for the hatchery. The local hatchery which depends on selling practically all chicks at the hatchery must be located where there is a good demand for chicks and must be readily accessible to chick buyers who call for the chicks.

The hatchery. The building which houses the hatchery should be built of substantial material and so constructed that it will withstand outside temperature fluctuations reasonably well. It should be kept in good repair, well painted, and present an attractive appearance. A well-drained concrete floor is conducive to cleanliness in the hatchery. The hatchery should be well lighted



U. S. D. A., A. M. S

Fig. 5–14. Commercial hatcheries in the United States 1934–1959.

and properly ventilated. Good lighting improves the work of employees and makes a good impression on customers. A well-ventilated building makes possible proper incubator ventilation. Forced ventilation is necessary in larger hatcheries, particularly in warm weather, to remove stale air and excess humidity, and to reduce the temperature. The building should be so arranged and a schedule of work so planned that the hatchery will be clean when customers come in. Every commercial hatchery should have at least separate rooms for the office, incubators, and for started or display chicks. Usually it requires only a little material and a small amount of labor to provide these minimum facilities. Other desirable rooms are egg receiving and traying room, chick sorting and boxing room, room for chick boxes and other supplies, and a display room for equipment and feed.

Battery brooders are used by most hatcheries for holding surplus chicks which accumulate because of weather conditions, order cancellations, or oversettings.

The manager. The most important single factor making for success in the hatchery business is the manager. A good manager may build a profitable hatchery business even where the conditions are unfavorable, but a poor manager may ruin the best hatchery. The management problem is the chain hatchery operator's greatest worry. The most successful manager is one who knows the poultry business as well as the hatchery business, possesses a strong personality, and has business ability.

Hatching egg supply. A supply of hatching eggs from healthy, well-bred flocks is essential to the continued operation of a hatchery. Few hatcherymen own enough birds to supply all the eggs required by their hatcheries and therefore they must purchase eggs from co-operating flock owners. In many communities good breeding flocks are not available and therefore it becomes necessary to ship in part or all of the eggs required. The most satisfactory arrangement is to get eggs from flocks located nearby so that the eggs can be delivered to the hatchery by the flock owner. The number of birds required to supply hatching eggs to a commercial hatchery is approximately one tenth of the egg capacity of the hatchery.

The servicing of hatchery supply flocks is essential if reliable sources of hatching eggs are to be maintained. Those hatcheries which hope to produce quality chicks must select good breeding flocks and know how they are managed. The cost of competent servicing for flocks is more than paid for by the improved quality of the chicks. The hatcheries generally make a service charge to the flock owner for culling and blood testing. Too often this is the only servicing the flock receives. All flocks should be visited before the hatching season begins and a careful check made as to the condition of the males and females in the flock and the feeding and management of the flock.

Many hatcherymen prefer to have some of the flock servicing done by trained state inspectors. These inspectors have or develop a background which is valuable in advising flock owners about their poultry problems. All states have poultry improvement programs with qualified field representatives who work with hatcherymen and hatchery flock owners. Agreements between the hatcherymen and flock owners are desirable so that each party may understand his responsibilities. Many hatcherymen have oral agreements with their flock owners which both parties respect.

The premium paid for hatching eggs varies with the quality of stock, the locality, the competition, the hatchability of the eggs, and the value of other services rendered. Most hatcheries pay a straight premium but some hatcherymen grade their flocks and pay a premium based on the quality of the flock, while others base the premium on the hatchability of the eggs.

The hatcheryman should make the flock owner a definite part of his hatchery organization. He should assist the flock owners with their poultry problems and make the flock owners feel that they have a definite responsibility to the hatchery. Flock owners should be boosters in their neighborhoods for the hatchery.

Hatchery sanitation. Cleanliness and sanitation in the hatchery are essential for continued success in putting out chicks which live and do not spread disease. Unfortunately, some hatcheries spread poultry diseases such as pullorum and bronchitis through their chicks and thereby create a bad reputation for hatchery chicks. Frequently chicks infected with bronchitis are shipped in the same car with other chicks or mixed with healthy chicks in the brooders, thus spreading this disease to chicks which were free of this trouble. It is to the interest of each hatchery that all hatcheries produce chicks free from such diseases as bronchitis.

Pullorum is the most common chick disease which may be spread through the hatchery. However, modern methods of blood testing the breeding stock and fumigating the incubators (p. 322) make possible the control of this disease. Progressive hatcherymen blood test (p. 322) the breeding stock used for producing hatching eggs. They also fumigate the hatching compartments of their incubators between hatches, using formaldehyde gas, which kills any pullorum organisms left by the previous hatch. Between hatching seasons the incubators, incubator room, brooder room, and brooding equipment should be thoroughly cleaned and disinfected.

Between hatches during the hatching season the hatching compartment should be fumigated with formaldehyde gas, using 40 cc. of a 40 per cent solution of formalin and 20 grams of potassium permanganate for each 100 cubic feet of space inside the compartment. The potassium permanganate should be placed in a glass or earthenware container and the formalin poured over it. Another method for liberating the formaldehyde gas is to saturate cheesecloth with the formalin and then hang the cloth near the fans in the incubator. To be most effective, fumigation should be done with both the temperature and humidity of the machine at the highest levels used in incubation. If the dry bulb reading is 100° F., the wet bulb thermometer should register at least 90° F. Since chicks which live well are excellent advertising for a hatchery and since pullorum disease is the most common cause of early chick mortality, it behooves every hatcheryman to control this disease. Time and money expended in blood testing breeding stock and for sanitation in the hatchery may be considered advertising expense.

To prevent the spread of pullorum disease in the incubator, the chicks may be fumigated according to the following procedure:

Calculate the exact number of cubic feet in the compartment to be fumigated. Use 35 cc. of fresh formalin and 17.5 grams of potassium permanganate per 100 cubic feet of space inside the compartment to be fumigated. Make the first fumigation when about 10 per cent of the chicks are out and before any have dried off. Twelve hours later repeat the fumigation. After each fumigation keep all ventilators closed for from 8 to 10 minutes, *but no longer.*

Remove all chicks hatched soon after the second fumigation. Twelve hours after the second fumigation make a third fumigation and again soon thereafter remove the chicks.

Be sure that the wet bulb reading shows about 70 per cent relative humidity throughout the hatch. *High humidity is very important.* Chicks may appear to suffer but if the correct amounts of materials are used and the above instructions are followed, results will be entirely satisfactory.

The prevention and control of infectious bronchitis has during recent years become an important problem in hatchery management. Every hatcheryman should follow practices designed to keep the disease out of the hatchery. Chicks should not be brooded in the incubator room; chick boxes and poultry coops previously used and adult birds should not be brought on the hatchery premises, and the hatchery room and equipment should be kept clean. In case of an outbreak in the hatchery plant, all affected chicks should be killed,

U. S. D. A.

Fig. 5–15 Sorting and boxing chicks for shipment. Note the storage racks on the left and openings in the chick boxes for ventilation.

other chicks moved from the incubator room, and all equipment used for brooding chicks thoroughly cleaned and disinfected, and the building fumigated with formaldehyde gas, using two and one-half times the amount recommended for incubator fumigation. The walls and floors should be wet thoroughly to increase the humidity of the room and the temperature should be raised to 90° F. to make the gas more effective. The room should be closed tightly for twenty minutes following fumigation. Fans should be operated in the room to distribute the gas during fumigation and to eliminate it after twenty minutes of fumigation. It has been observed that an outbreak of this disease spreads quite generally in a territory. Hatcherymen located in such a territory should exercise extreme caution in preventing an outbreak in their plants Preventive vaccination (p. 336) may also be used.

Hatchery waste. Infertile eggs, dead embryos, cull chicks, cockerel chicks, and egg shells from hatched chicks, constitute valuable animal food material. The material is frequently given to hog raisers for hauling it away from the hatchery. The larger hatcheries sometimes find it profitable to sell the infertile eggs and dead embryos for pet foods. Or, the entire material may be cooked, dried, ground, and sold as chicken tankage. As such, it is more suitable for use in laying rations than for other purposes, because of its high shell (calcium carbonate) content.

Hatching season. The hatching season varies with the geographical location and weather conditions. In the United States most chicks are sold during March, April, and May. Most hatcheries make their first settings in Janu-

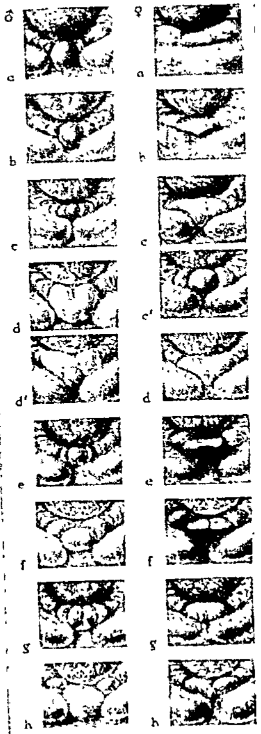
ary or February and bring off their last hatches in June. Severely cold weather may delay the opening of the chick season and an early drought may abruptly end the season. Some hatcheries operate throughout most of the year and a considerable number now operate during the fall months to supply the chicks demanded for winter broiler production.

Surplus chicks. The modern hatchery is prepared to handle some surplus chicks. Floods and snow and ice storms frequently cause the demand for chicks to be postponed and the hatcheryman who had anticipated the demand on the basis of normal weather conditions finds that more chicks hatch than can be sold. By carrying these chicks in battery brooders until favorable weather prevails, they can be moved through the regular chick sales without dumping them on auctions or selling them at reduced prices.

Surplus chicks are the greatest menace to the maintenance of chick prices. If surpluses occur early in the season, they may demoralize the price structure for most of the season.

Surplus chicks are sometimes sold at auctions for much less than the cost of production. The disposal of surplus chicks leads to unethical trade practices.

Sexing chicks. The sexed chick business has developed rapidly since it was introduced on the West Coast in 1934. Today nearly all commercial egg production stock is sexed at the time of hatching (Fig. 5–16 and 17). The cost is usually twice as much compared to unsexed chicks, with a charge of 0.5 to 1.0 cent per



COURTESY T. H. CANFIELD UNIVERSITY OF MINNESOTA

Fig. 5–16. Chick sexing. Diagrams of the everted cloacas of chicks showing the different structures observed in male chicks (left) and female chicks (right). Note the great variation in the appearance of both the males and females.

chick. For instance, if a hatchery is selling chicks at hatching time for 17 cents, it will usually charge 35 cents per chick for the sexed pullets. The Leghorn cockerels are not worth growing for broilers because of their small size and feed requirements per pound of gain. They are usually killed and discarded with the hatchery refuse.

Chicks are sexed by two principal methods: (1) Examination of the cloacal wall (Fig. 5–16), and (2) examination for testes or ovary by insertion of a small light into the cloaca (Fig. 5–17). Both procedures require considerable skill and training. Chick sexing is highly accurate when done by people trained for the work. They are capable of sexing 500 to 1,000 chicks per hour.

Custom hatching. Small community hatcheries formerly obtained considerable income for hatching eggs for farmers in the community. The charge was generally $2.00 per 100 eggs set. The larger hatcheries are not interested in custom hatching today. Most of them are in the National Poultry Improvement Plan (p. 106). The stock from which all hatching eggs are set must have been tested for pullorum disease. Owners of small flocks often neglect to take this precaution when hatching eggs.

Culling chicks. It is just as important to cull chicks as to select laying stock (Fig. 5–15). All weak and crippled chicks should be destroyed. They mar the appearance of the group and often succumb to the attacks of disease and thereby spread infection to healthy chicks. It is also important that "off-colored" chicks be removed from the group, particularly if the chicks are to be sold. Chick customers are quite critical of chicks that show impurity of breeding, often judging the entire group by one or two "off-colored" chicks. The Standard of Perfection contains color descriptions of the different varieties of chicks. The producer of baby chicks should be familiar with these descriptions. Complaints may be reduced by acquainting customers with the proper color markings of the chicks they purchase as chick customers are often misinformed as to the correct color of baby chicks.

Delivering chicks. Small local hatcheries deliver most of the chicks they sell directly to the buyer at the hatchery. The hatcheryman is therefore relieved of the costs of transportation and the hazards of shipping. Some hatcheries are now making local deliveries by truck to the poultryman. As competition increases, this practice will likely become more common.

Chicks are shipped by express and parcel post. During the spring months losses are negligible but in hot weather losses may run quite high. Hatcheries make a practice of guaranteeing 100 per cent live delivery.

The ventilation of the boxes is quite important. It should be kept in mind that in cold weather the chicks are kept warm in the boxes by their body heat. In cold weather very few holes should be punched in the boxes, but in hot weather the boxes should be well ventilated. Some hatcheries replace most of the top of the box with screen wire when shipping chicks during the summer months.

The standard containers for delivering chicks are cardboard boxes in sizes suitable for 25, 50, and 100 chicks. The standard chick box for 100 chicks is 22" x 18" x 5½". For hot weather shipments larger boxes (24" x 18" x 6")

Fig. 5–17. Detecting the sex of day-old chicks by observing the gonads (testes or ovaries) of the chicks. (Courtesy of the American Chick-Sexing Association.)

are used. Special chick box supply houses provide the hatcheries with their shipping supplies.

Business methods. Financial success in the hatchery business, as in all business enterprises, is dependent upon good business methods. A complete set of records should be kept in every hatchery. Such records should not only show all financial transactions but should also show the inquiries received, the name and address of customers, the number and grade of chicks sold to each customer, the date of each sale, and a record of all hatching eggs purchased. See chapter twelve for chick production costs.

Marketing chicks. The marketing of chicks is the hatcheryman's sales problem. There are three common methods of selling chicks: local sales at the hatchery, mail orders direct to customers, and wholesale. The wholesale method is the least satisfactory and most destructive of chick quality. This method prevents contact between the producer and customer, an arrangement vital to the improvement of quality. Local chick sales are most satisfactory and are less expensive than mail order sales. In every community there is a demand for high-quality chicks that can be supplied by the local hatchery.

Advertising. The best advertisement any hatchery can have is the chicks it produces. Quality chicks sell themselves and also stimulate repeat orders. Many hatcheries sell their entire output primarily upon the reputation of the chicks produced in previous seasons. A satisfied customer not only buys the next year but also influences others to buy. This form of advertising should be carefully guarded by every producer of chicks.

COURTESY AMERICAN POULTRY AND HATCHERY FEDERATION

Fig. 5–18. A scene in the exhibit area of an American Poultry and Hatchery Federation. The federation meets annually with thousands of hatcherymen and members of allied industries in attendance.

A neatly kept plant is another inexpensive but very effective method of advertising. Visitors are interested in cleanliness around the hatchery. Every visitor is a prospective customer and should be considered as such.

Attractive advertising signs and buildings are good advertising particularly for the local demand. Well-painted and well-kept buildings should be considered a part of the advertising program of every hatchery. Advertisements in the local newspaper stimulate local demand and should be used as a means of reaching this outlet. Often news stories of local interest about the hatchery or its products serve as splendid advertising. Advertising on a state-wide or nation-wide scale should be conducted by an advertising specialist whose services are available to the hatcheryman through various advertising agencies. Catalogs and other advertising material should be prepared by advertising specialists.

Shipping hatching eggs. Some states have developed important hatching egg outlets because of their favorable climatic conditions and location in the United States. Hatching eggs are shipped by express (Fig. 5–19) and by truck. Eggs intended for the use of hatcheries should be carefully graded for size, and eggs weighing less than twenty-three ounces per dozen should never be sold to hatcherymen without a very definite understanding about the size of the eggs Extra long or large eggs which are likely to be broken in transit should not be shipped as hatching eggs. Hatching eggs should also be graded for shape and color Eggs from varieties which lay white-shelled eggs should be chalk white and reasonably free from tints For best results the eggs should not be over one week old. They should be packed with the small end down in new cases, with flats and fillers Eggs shipped with the small end up do not

NICHOLS, INC., EXETER, NEW HAMPSHIRE

Fig. 5–19. Shipping hatching eggs by air.

hatch well. The use of new flats and fillers will prevent damage to the eggs. The case tops should be nailed down at each end but not in the middle, with four-penny cement-coated egg-case nails. Each case should carry a label showing the name of the buyer, the name of the shipper, and the fact that the eggs are hatching eggs. If the eggs are from a hatchery co-operating with the National Poultry Improvement Plan and are being shipped to another hatchery operating under the plan, they should carry an official label indicating the breeding stage and pullorum control class. Inside the case on top of the eggs

there should be a slip showing the number of dozens and the breed and variety of chickens which produced the eggs.

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Chapter 6

Brooding and Rearing

A PROFITABLE POULTRY ENTERPRISE depends upon a successful brooding and rearing program. Such a program includes control of the chicks environment, proper housing and management, and the control of diseases and parasites.

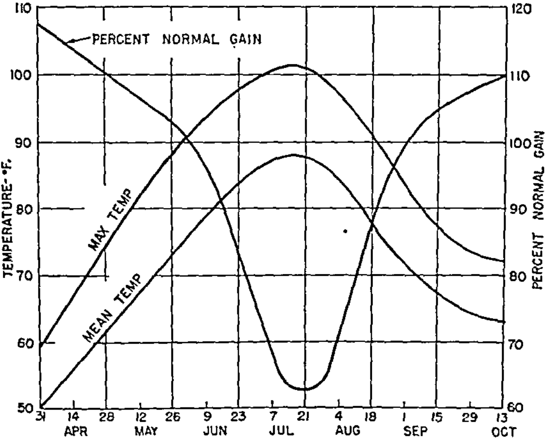
Environmental Conditions in Brooding

There are certain environmental conditions which must be controlled when brooding chicks. These are temperature, ventilation, humidity, sanitation, and space.

Temperature. There are optimum temperatures for chicks of different ages. Temperatures too high or too low will slow down the growth rate and may cause death (Fig. 6–1). The most satisfactory arrangement is a temperature range of 90–95° F. down to 60° F. allowing the day-old chicks a choice of the most comfortable temperature. Young chicks must have some source of heat for the first few weeks of their lives, the amount and time varying with environmental temperature conditions. Experiments at the Beltsville Agricultural Research Center proved that maximum growth and feed efficiency was obtained when the temperature was started at 94° F. on the first day and reduced uniformly to 80° F. on the 18th day. Thus, the common recommendation of starting the brooder at 95° F. (2 inches above the litter at the edge of hover) and gradually reducing the temperature about five degrees each week is well founded. The most important thing to consider in brooding is to keep the chicks comfortable and to avoid extremes in temperature.

If the body temperature of the chick reaches 117° F., it will die. The California Station has reported that chicks held in sealed, summer-size, fibre board boxes in a room kept at 100° F. suffered losses of 20 to 50 per cent. Leghorn chicks suffered less than New Hampshire chicks.

Chilling. Heavy losses may result when chicks become chilled. Chicks infected with pullorum suffer more from chilling than chicks free of this disease. Chilling may affect the lungs and result in paralysis of the breathing mechanism Chicks that are chilled tend to crowd and pile which may cause heavy losses. Diarrhea may be caused by chilling and growth may be retarded. The Maryland Station reported experiments in which they found that chicks (0–4 days old) exposed for 30 to 40 minutes at 10° F. died from such exposure Older chicks (18–20 days) died after 70–80 minutes of such exposure. The lethal body temperature for day-old chicks was found to be 60° F., and it increased progressively to 72° F. as the chicken reached maturity.



PURDUE AGR. EXT. SERVICE LEAFLET (378)

Fig. 6–1. This graph shows the influence of temperature on growth gain of poultry.

Ventilation. Fresh air is essential to the developing chick, and ventilation is necessary to keep the house reasonably dry. Carbon monoxide may be formed by defective combustion of such fuels as gas, oil, and coal. If this gas accumulates to a concentration of 0.01 per cent, slow poisoning may occur. A laboratory examination of the blood is necessary to determine carbon monoxide poisoning.

If sufficient ventilation is used to keep the litter reasonably dry and to eliminate foul odors, the chicks will have an adequate supply of fresh air and they will not suffer ill effects from harmful gases. Ammonia fumes from built-up litter and droppings may become obnoxious in tightly closed brooder houses. Such fumes irritate the chicks' eyes.

Moisture. Too much or too little moisture in the brooder house may cause trouble. If the litter or walls and ceiling become wet, there is too much moisture in the brooder house and efforts should be made to reduce it. Wet litter may lead to an outbreak of coccidiosis or other diseases. The litter must be kept reasonably dry. By increasing ventilation, the condition of the litter can be improved and kept dry. If moisture condenses on the ceiling and walls until it drips, better insulation and ventilation is needed.

A brooder house may be too dry for chicks. A fairly humid environment (50 to 60% R.H) is conducive to good feathering. A very dry atmosphere will cause poor feathering.

Floor space. For best results in brooding, the chicks should have plenty of floor space. A good rule to follow is to allow ½ square foot of floor space per chick, and to increase the space by ½ square foot per chicken each four weeks until the pullets are ready for the laying house. There, they should have 1 to 3 square feet of floor space per bird. Broilers require ¾ to 1.0 square foot of floor space to market age.

Management in Brooding

Proper brooding management is essential to raising healthy pullets or broilers.

Litter. Several days before the chicks are placed in the brooder house, it should be thoroughly cleaned and disinfected (unless chicks are to be brooded on old litter). Fresh, clean litter should be added to 2 or 3 inches in depth. Shavings, sawdust, crushed corn cobs, peat moss, sugar cane pulp, or other absorptive materials may be used as litter.

The question of old versus fresh litter remains debatable. Many poultry managers favor old litter because it saves labor. However, it may become infested with worms (particularly in the South), coccidia (if the litter becomes wet) and other organisms. Old litter does contain some nutritional factors such as B_{12}, riboflavin, and possibly other factors not found in fresh litter.

Whenever fresh litter is used, it must be clean, dry, and free of mold and dust. The mold, aspergilliosis fumigatus, which is sometimes found in litter or feed, may cause heavy losses from what is commonly called brooder pneumonia.

Young chicks and poults sometimes die from crop impaction resulting from eating litter. To prevent this hazard, the litter may be covered with newspapers, to be torn up by chicks and mixed with the litter. In fact, newspapers serve to attract the chicks to the hover at night because chicks tend to gather on them. If the chicks are not too hungry when they are placed in the brooder and feed is kept before them, they will not eat litter. Feed and water should be ready for the chicks when they are placed in the brooder. A good way to start chicks eating is to place feed on egg cup-flats, newspapers, chick box lids turned upside down and covered with paper, or cut down chick boxes.

Comparison of litters. The Delaware Station compared several litters used for brooding broilers and their conclusions were:

1. Litters of organic origin were found to be superior to litters of inorganic origin for use in broiler production
2. Litters of inorganic origin, or mineral litter, increase dustiness in broiler pens, which in turn increases the severity of respiratory diseases.
3. Based upon broiler production factors and observations, the twelve litters studied may be ranked for superiority in the following order: peanut shells, ground corn cobs, peat moss, sugar cane fiber, sawdust, shavings, cottonseed hulls, corn stalks, dryzone, sand, chick bed and Georgia mineral litter.
4. The best litter for broiler production is one that is of organic origin,

dry, fine in texture, light in weight, relatively free of dust, low fire hazard, and relatively low in price.

Feeding. One of the major problems in raising young stock or broilers is to get the most efficient gains or feed utilization. The rations used and the rate of growth of the stock are the most important factors affecting feed conversion. The method of feeding employed and the feeder (human element) are also very important.

Self feeders are generally employed for replacement stock, especially on the range. They save labor in feeding, and if kept filled, provide feed at all times.

For the most profitable returns, hand feeding will give better gains and better feed conversion than self feeders. Therefore, most managers who raise broilers have abandoned self feeders and renewed hand feeding in troughs (Fig. 6–2). The more efficient managers continue to work through the house adding fresh feed or stirring the mash in the troughs. Such feeding encourages feed consumption.

The use of mechanical feeders in large scale broiler enterprises has been generally adopted in recent years (Fig. 6–4). Due to mechanical difficulties and for other reasons, some growers have abandoned mechanical feeders. If properly used, mechanical feeders give results equal to hand feeding. However, it should be noted that mechanical feeding is only another method of feeding and close supervision is required. Such feeders cannot entirely replace the manager, who is the key to success in either mechanical or hand feeding.

Within recent years, bulk feeding has been developed (Fig. 6–5). Large trucks equipped with conveyors to handle several tons of feed, move the bulk feeds directly from the feed mill to the feed bins of the grower to which mechanical feeders may be connected. Bulk feeding is adapted only to relatively large scale operations.

Four, 3-foot trough-type feeders will provide sufficient feeding space for 100 growing pullets.

Water. Fresh water is necessary at all times for satisfactory growth and efficient utilization of feed. It is frequently neglected if only a few chicks are brooded. Broiler raisers realize the importance of fresh water and provide either running water or water under pressure with automatic controls to provide a constant supply of fresh water (Fig. 6–3).

One of the drudgeries in raising a small flock on general farms, was the carrying of water. But with the widespread use of electric pumps and pressure systems to supply water needs, water is being piped to brooder houses and to the range where pullets are raised. If electricity is not available, or if the range is too far from the water supply to make a water line practical, barrel type waterers with a float may be used to provide water with a minimum of labor (Fig. 6–6).

Quart jar water founts are suitable for starting chicks and 3 to 5 gallon glass or metal water fountains are useful during the brooding period when the chicks need heat. A 3 to 5 gallon waterer will care for 100 chicks. Later on

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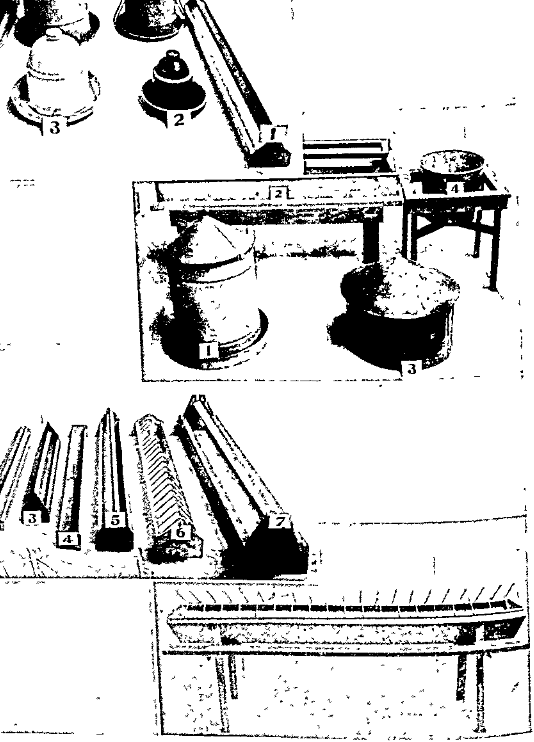


Fig 6-2. The use of equipment which keeps the birds out of the feed and water will reduce contamination by droppings, and therefore lessen the spread of bacterial and parasitic diseases. Upper, 2, 3, 5, and 6 in left half and 1 on right half, drinking vessels for small chicks; 3 and 4 in right half, drinking vessels for pullets, 1 and 4, left half, feed hoppers for chicks; 2 right half, feed hopper for mature birds Lower, 1 to 4, mash hoppers for small chicks; 5 to 7, mash hoppers for pullets. Right, sanitary hopper for mature birds.

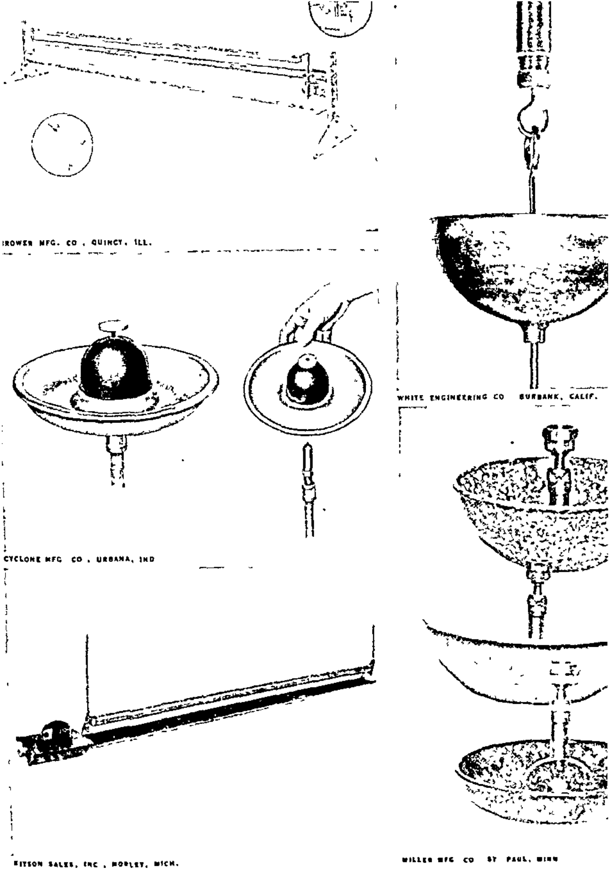
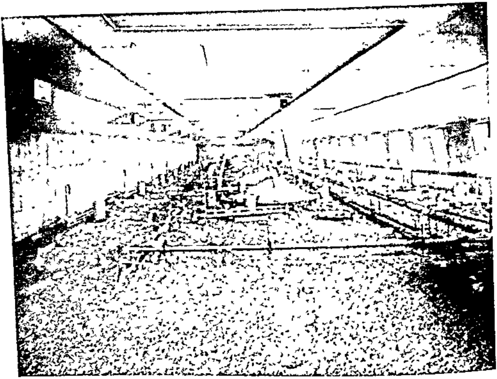
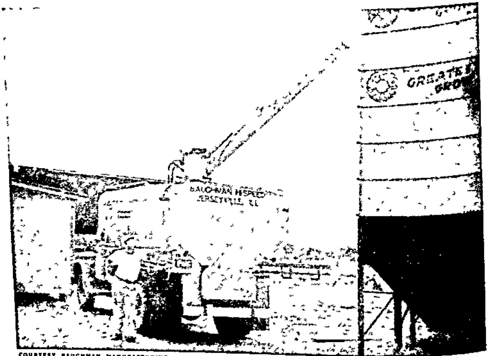


Fig. 6-3. Top, left, Stand trough. Middle, Fountain. Bottom, Hanging trough. Top, right, Hanging bowl. Bottom, Bowls.



COURTESY JAMES MFG CO., FORT ATKINSON, WISC.

Fig. 6–4. Mechanical feeders are used for feeding large numbers of chicks.



COURTESY BAUGHMAN MANUFACTURING CO., JERSEYVILLE, ILLINOIS

Fig. 6–5. Bulk feed truck unloading feed into a bulk bin.

range, a barrel waterer with a float valve will supply water for 150 to 200 pullets.

COURTESY MO. AGR. EXT. SER.

Fig. 6–6. Barrel waterer with float valve in use on range. *Range feed hopper at right.*

Heating Systems and Methods

There are several sources of heat and different methods of heating brooder houses that produce satisfactory results. Individual brooder stoves and central heating systems are both used.

Central heating systems cost more per chick to install but they are less expensive (per chick) to operate. They require less labor to operate and are less fire hazardous than individual stoves.

Individual pen brooders. These are adapted to either small or large operations (Fig. 6–10). They cost less to install than the central heating systems, but they cost more per chick to operate. They require more attention and labor than the central systems.

Coal stoves. Coal stoves have been used for a longer time than other type brooders. They are still used by farmers and broiler raisers, but in recent years their use in new brooder houses has declined. They have an advantage in providing sufficient heat to keep the house warm and dry in cold weather, but they require more attention and labor than some of the other brooder units which accounts for their decline in popularity.

Coal stoves are provided with thermostats that control the draft and temperature. These thermostats should be checked in sufficient time before the stove is to be used so that defective parts can be detected before the stove is started. The smoke pipe should have a metal guard surrounding the opening in the roof through which the pipe passes, to prevent setting the roof on fire. To insure sufficient draft, the pipe should extend about three feet above the roof. A metal cap over the end of the pipe will help prevent back drafts and rain from running into the pipe. The pipe should also be equipped with a draft damper.

Chestnut-sized anthracite coal is best for coal stoves, but it is not always available. Briquets of soft coal are commonly used and are satisfactory if the pipe is kept reasonably clean of soot. Some experience in operating coal stoves is helpful. The beginner will do well to light such stoves several days before the chicks are to be started, to learn how to operate them at a uniform temperature.

Wood-burning brooders. A few years ago wood burning brooders became popular in areas where wood was readily available, but they have lost

popularity because of the labor involved in providing wood, and because some of them require close attention to maintain a satisfactory temperature. Some brooders are equipped with reliable thermostats which are effective in maintaining the desired temperature. When green wood is used, tar may clog the smoke pipe.

Oil-burning brooders. These brooders require less labor to operate than coal or wood-burning stoves. With thermostatic control, they maintain a uniform temperature and provide ample heat to keep the house warm and dry; but the fuel-oil cost of operating them is relatively high, and there is a greater fire hazard than with other types of brooders.

Gas-burning brooders. Within recent years, gas-burning brooders have become quite common because natural gas is being piped throughout the country and bottle gas is widely distributed in rural areas. One stove or many may be operated from one gas tank. Different sized bottle gas tanks are available for small or large installations. These brooders maintain uniform temperatures and require a minimum of labor to operate. They are usually connected to the gas line with a rubber hose and are suspended from the ceiling with a rope and pulley attachment so that they can be adjusted to any height or raised up and out of the way for cleaning or doing other work.

Disadvantages are: (1) do not provide enough heat to keep the brooder room warm in cold weather in the central and northern parts of the United States and, (2) cause moisture to condense in the house during winter.

Electric brooders. With increased use of electricity in rural areas, electric brooders have come into general use. They maintain uniform temperature under the hover and require little attention. However, they do not heat the room, and in cold weather, wet litter is more troublesome than with coal or oil stoves. They are also dependent on a constant electric current.

Infra-red brooding. This is a relatively new method for brooding chicks and it may find a place in poultry raising. Infra-red lamps are suspended (18 to 27 inches) above the floor litter (Fig. 6–10). These lamps do not heat the air, but they warm the chicks as do the direct rays of the sun. The comfort of the chicks is the guide to be followed in infra-red brooding and not the thermometer. A single 250 watt infra-red bulb will provide for 60–100 chicks. Multiple units are available or may be constructed with several bulbs per panel. Thermostatic controls are desirable on these multiple unit installations to save electricity.

The advantages of infra-red brooding are: (1) low initial cost, (2) minimum of labor, (3) easy to install and operate, and (4) all chicks can be seen at any time. Some of the disadvantages are: (1) insufficient heat in cold weather, (2) problem of power interruption, and (3) high cost of operation. Work reported by the Delaware Station showed that infra-red brooding resulted in a marked increase in barebacks.

Unit space heaters. Heating units similar to those used in heating garages, factories, etc. (Fig. 6–12) are being used in some brooding operations. Fans drive air through a radiator heated with steam or hot water and circulate the hot air through the brooder room. The air currents are directed in such a manner as to keep the chicks comfortable and spread out over the floor.

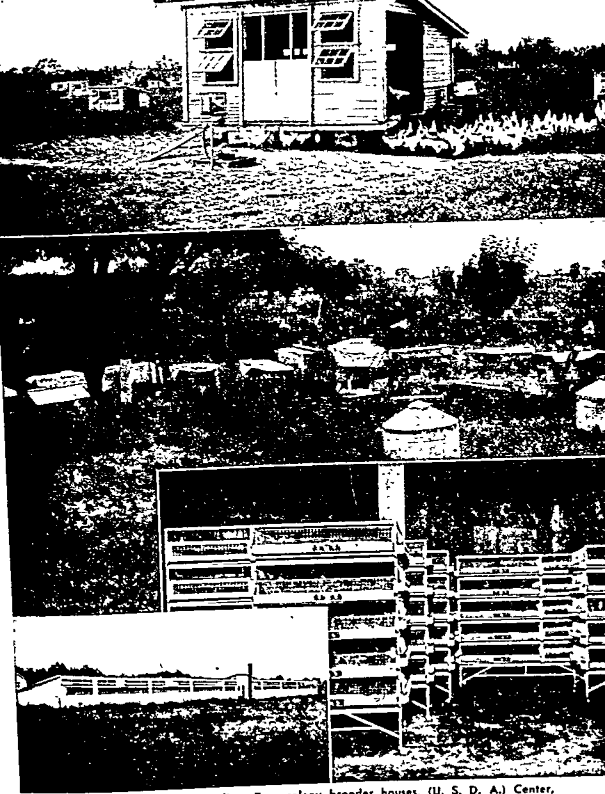


Fig. 6–7. Evolution in chick brooding. Top, colony brooder houses. (U. S. D. A.) Center, natural brooding with hens. (U. S. D. A.) Bottom left, multiple-unit brooder house with central heating plant. Bottom right, battery brooding.

Central Heating Systems

Commercial production has created a demand for brooding systems to handle 5,000 to 25,000 or more chicks per house. Several different central heating systems have been developed for such use. These systems use either coal, oil, or gas for fuel. Automatic stokers on coal-fired furnaces reduce labor and

insure even heating. The oil-fired furnaces cost less to install but with current prices of oil, they are more expensive to operate than coal-fired furnaces.

Hot water heat. This type of brooding system has given satisfaction in large scale operations for many years. Hot water pipes (1¼") spaced 4 to 6 inches apart and about 14" above the floor are used for circulating the hot water (170 to 190° F.) (Fig. 6–12). Circulators (pumps) are used to circulate the water. A thermostat controls the circulators and an aquastat regulates the fire controlling the temperature of the water. The hot water system of brooding holds heat well and maintains a uniform supply of heat. Installation costs are high but fuel cost per chick is very low.

Radiant hot water systems. Hot water pipes above the floor are very much in the way when cleaning and catching chickens. Some operators have built houses with the hot water pipes buried in the concrete floor. This has been called radiant heating. This is an expensive system to install because it requires a concrete floor (not generally used now) and a central hot water heating system. These costs may be as great as the other costs of the house. Radiant heating has lost its appeal since it has not fulfilled all claims made by its advocates.

Central hot air heat. The system used may be either direct or indirect. In the direct hot-air system the air is heated by a hot air furnace and distributed through a central duct to the chicks; pipes lead off from the central duct at 15 foot intervals to about 15–18 inches from the floor (no hover is used).

Another type of direct hot air heating circulates the hot air through a central duct (12 inch pipe) beneath a hover. Holes in the top of the pipe permit the hot air to escape and be deflected down to the chicks by the hover.

An indirect warm-air heating system has been built by some large scale (20,000 to 40,000 broilers) operators. Steam is piped from a furnace to the center of the pen where a heat exchanger is located. Fresh air is heated by a fin-type steam radiator. The hot air is then blown through a central duct and distributed as described above for the direct hot-air system.

Battery Brooding

After vitamin D was discovered and incorporated in poultry rations it was possible to raise chickens in complete confinement away from direct sunlight. These developments made possible the brooding of chicks in battery brooders (Fig. 6–7).

Types of battery brooders. There are two general types of battery brooders: (1) the unheated brooders made for use in warm rooms, and (2) those equipped with heating units and warm compartments for use in rooms held at 60 to 70° F. Most batteries in use today for young chicks have heating units which are heated by electricity and each compartment is equipped with a thermostat for regulating the temperature.

The use of battery brooders. Battery brooders may be used to start chicks for flock replacements, for broiler production, for started chick sales, for holding surplus chicks, or for chick feeding experiments, etc. For best results, their use in starting chicks for pullets to replace flocks is limited to the

Fig. 6–8. Colony brooders. Top left, oil brooder. (Courtesy Simplex Brooder Stove Company.) Top right, electric brooder. (Ohio Extension Service.) Center, coal brooder. (Ohio Extension Service.) Bottom, wood brooder. (Courtesy Shenandoah Manufacturing Company.)

first three or four weeks of the chick's life. Broilers may be grown in battery brooders if they are to be killed and dressed on or nearby the premises.

At one time batteries were widely used to brood 3-week-old started pullets. Disease hazards and excessive express rates have since almost eliminated the started chick business.

Fig. 6–9. Range shelters used for rearing pullets on range after heat is no longer needed.

An Evaluation of Brooding Systems

The Delaware Station reported the results of studies made of types of brooding for the production of broilers (Table 6–1).

Table 6–1

COMPARATIVE COSTS OF INSTALLING AND OPERATING DIFFERENT BROODING SYSTEMS [1]

System	Installation Cost (cents) per Chick	Fuel Cost (cents) per Chick Started
Central		
Hot water (coal-fired)	20–25	0.6
Hot water (oil-fired)	20–25	1.0
Direct hot air (oil-fired)	16–20	1.5
Indirect warm air (coal-fired)	12–18	1.0
Infrared	18–20	2.7
Individual stoves		
Oil	7	2.3
Coal	8	1.9
Gas	9–11	1.6
Electric	10	1.5

[1] From Delaware Agr. Exp. Sta. Bul. 50, November 1950.

"The central hot air system of brooding broilers gave results comparable to the results with individual coal burning brooders. Observations would indicate that the effectiveness of the hot air system would be greatly enhanced if installed in a well-insulated broiler house.

"Oil burning brooders produced higher average final broiler weight in two trials than did individual coal stoves. When the results of the two trials are combined, mortality was slightly lower in the oil brooded broilers than in the coal brooded pens. The value of the increased weight of poultry produced indicates that oil burning brooders are slightly more efficient than individual coal burning brooders. Oil burning brooders have the added advantage that they should require less labor to operate.

OHIO EXTENSION LEAFLET L 62

Fig. 6–10. Brooding with infra-red heat lamps. Note the guard to keep the chicks near the lamps the first few days.

"The use of infra-red bulbs in brooding broilers resulted in an increase in the number of poorly feathered birds and an increase in the fuel costs, as compared with individual coal burning brooder stoves. There was little difference between the two systems of brooding in broiler mortality, average final weight, and feed required per pound of broiler sold.

"A relative evaluation of the brooding systems studied, based upon broiler production results, fuel costs, and general observations would seem to justify the following order: (1) Central hot air, (2) oil stoves, (3) individual coal stoves, (4) gas stoves, and (5) infra-red bulbs."

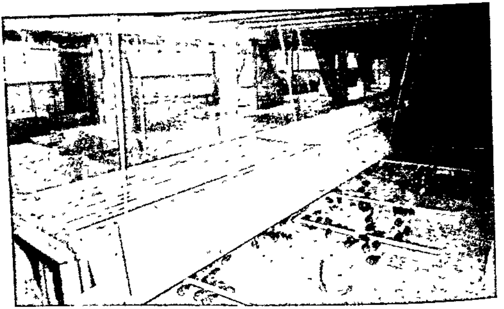
The Delaware Station compared gas, oil, central hot air, infra-red, and coal brooders. From their experiments they concluded:

". . . gas-heated brooders gave production results equal to individual coal-heated brooders, but the cost of gas fuel was greater by 26.8 per cent . . .

Brooder Houses

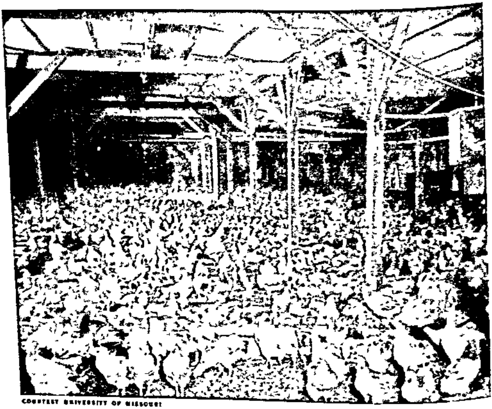
The kind of brooder house to use depends upon the climate and the type of poultry enterprise. The housing requirements in the northern states for winter brooding are quite different from those of the south. The kind of brooder house needed by a general farmer keeping a laying flock of 200 to 300 hens is very different from that of a commercial broiler enterprise with several thousand broilers (Fig. 6–7).

Two types of brooder houses are generally used for brooding chicks for



ONIO EXTENSION LEAFLET L 62

Fig. 6–11. A hot water brooding system with the pipes about 18 inches above the floor.



COURTESY UNIVERSITY OF MISSOURI

Fig. 6–12. Commercial broiler production in large brooder houses with space heaters.

flock replacements—the colony house and the large, permanent brooder house. Each has a place in the poultry industry; however, the trend is to permanent houses.

Movable colony houses, 10′x 12′, built of wood and erected on skids, are used by farmers who raise only a few hundred chicks. These houses may be moved near the residence for starting the chicks and brooding them as long as they need heat. The house and the chicks can then be moved to clean range. Some who raise poultry, use a range shelter as a sun porch to the brooder house and then move only the range shelter and the pullets to range (Fig. 6–9).

Large-scale egg production enterprises are turning to large, permanent brooder houses equipped with either a central heating system or individual stoves. The pullets are usually moved to range and placed in range shelters after they no longer need heat. Many commercial producers of broilers and pullets are raising them in complete confinement without range.

Permanent brooder houses are built 20 feet wide or wider (Fig. 6–4 and 7). In some areas, small pen units with wire floors are used. These permanent brooder houses generally have a concrete foundation which gives permanence to the building and keeps out rats, etc. Many pole-type houses are also being built. Until recently, concrete floors were often installed, but with the general use of built-up litter, broiler raisers have turned to dirt or gravel floors since the houses are seldom cleaned. A concrete floor (thin section type) is practical if the brooder house is to be cleaned and disinfected between broods or annually. The roof used on most brooder houses constructed within recent years, is generally of the gable type with ridge ventilation (Fig. 7–26). In most parts of the United States (except the south and Pacific coast), it is worth the expense to insulate the roof or ceiling of the brooder house if it is to be used for brooding during winter.

Development of the Broiler Industry

The phenomenal growth of commercial broiler production in the United States in recent years illustrates the revolutionary change in American agriculture. The industry is relatively new, having developed mainly since World War II (Fig. 6–13). It had its beginning primarily in New England states and along the eastern seaboard near the larger consuming areas. Earlier, attempts to commercialize poultry meat production had failed because of inadequate rations and ineffective disease control; but with the discovery of vitamins required by poultry, the control of disease by vaccination, and the use of drugs, the broiler industry became commercial.

The industry shifted from New England to Del-Mar-Va and then to the South, because as competition increased and prices declined, areas having lower costs of production were in a position to expand production. The South had lower labor costs because labor did not have the alternative industrial opportunities that were available in the older broiler areas. Housing costs and the cost of brooding were also less in the South.

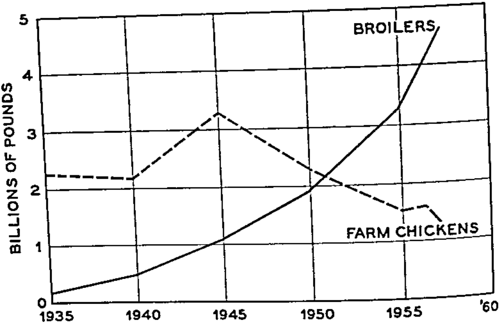


Fig. 6–13. Growth of broiler production in the United States.

If the labor advantage the South now enjoys should disappear, the broiler industry of the future might shift and be located near the consuming areas where feed is also produced. This is not likely to occur until present plants and equipment become obsolete.

As the population shifts, the consuming areas change. The large metropolitan areas are the principal markets for all agricultural products.

Breeds, strains or crosses to raise. The broiler raiser needs a fast growing, rapid-feathering bird which makes economical gains and dresses out as a quality bird that satisfies the consumer. There have been many shifts to better birds, and those breeders and hatcherymen who have failed to make the changes necessary to satisfy the raisers, have been forced out of business Purebred Barred Rocks, R. I. Reds, New Hampshires, White Wyandottes, and White Rocks were once the best stocks for broiler production, but in recent years special meat strains of female White Rocks and New Hampshires have been developed to mate with Cornish males. There has also been a shift to broilers with white or light colored feathers.

Fortunately, the industry may expect the breeders to continue their search for improved meat strains, and some that are popular today will be replaced by superior stocks later. The perfect bird or cross has not been found as yet.

Broiler tests. Random sample broiler tests have been established in a number of states for the purpose of comparing different strains and crosses for characteristics or qualities considered important in broiler production. An example of the information supplied by one of these tests is given in Table 6–2.

Housing. Broilers were once raised on range or in semiconfinement, but in recent years they have been grown in complete confinement. As a result,

Table 6–2

OVER-ALL AVERAGE PERFORMANCE OF ALL STOCKS ENTERED IN THE ARKANSAS TEST MATING MEAT PERFORMANCE BROILER TEST, SPRING 1958[2]

Fertility of eggs set	86.9
Hatchability of eggs set	80.4
Viability to 8 weeks	97.6
Feed per lb. chicken	2.10
Live wt. males, 8 wks.	3.31
Uniformity (100-coef. var.)	91.12
Live wt. females, 8 wks.	2.66
Uniformity	90.89
Males & females, avg. wt.	2.99
Cockerels, N. Y. dressed wt.	2.98
Cockerels, N. Y. dressed wt. %	88.96
Cockerels, eviscerated wt.	2.37
Cockerels, eviscerated wt. %	70.87
Cockerels, avg. keel length (in.)	3.29
Cockerels, avg. breast angle	84
Cockerels, fleshing—AA	22.0
Cockerels, fleshing—A	73.3
Cockerels, fleshing—B	4.7
Cockerels, fleshing—C	0.0

[2] The cockerels were also graded for finish and feathering.

Production Methods

the houses have been enlarged and made more permanent. Most modern broiler houses are pole-type, one-story, gable roof with ridge ventilation, rather wide (30 feet or more), and large enough for 5,000 to 10,000 broilers or more (Fig. 6–7 and 12). Each broiler should be allowed ¾ to 1.0 square foot of floor space.

Feeding. Broiler rations are discussed in Chapter 8. Most raisers are equipped to handle bulk feed which is delivered by trucks built especially to handle bulk feed and convey it into the bins (Fig. 6–5). The feed is then moved by gravity (Fig. 6–14) or conveyor to mechanical feeders (Fig. 6–4) which carries the feed to the birds. Those who hand feed their broilers properly can get slightly better growth and more efficient gains but mechanical feeders continue to gain in favor because they save labor.

The amount of feed required to produce a pound of broiler meat has continually declined as rations have been improved and the breeders have produced more efficient meat producing strains. Table 6–3 indicates the progress made in increasing the efficiency of broiler meat production.

Labor. The development of larger and more efficient houses and the use of mechanical feeders, automatic waterers, and other mechanical devices has reduced the labor required to produce broilers. While at one time 2,500 birds may have been considered a one-man unit of production, the number of broilers one man can grow at one time increased to 5,000, 10,000, 20,000 and

Table 6–3

INCREASED GROWTH AND IMPROVED FEED EFFICIENCY IN BROILERS [a]

Year	Breed or Cross	Age in Weeks	Avg. Wt. Lbs.	Lbs. Feed per Lb. Broiler
1934...........	White Rocks (Both sexes)	12	2.38	3.81
1951	White Rocks (Both sexes)	12	3.66	3.10
1958	Crosses in Ark. Test	8	males 3.31 females 2.66	2.10

[a] 1934 and 1951 data from Bechtel, General Mills.

30,000 or more. Thus the man hours required to produce broilers is now about $\frac{1}{10}$ of what it was 40 years ago.

Management

The management followed in the broiler plant may mean the difference between success and failure. Some men have the ability to judge the condition of birds and their needs better than others. They can sense trouble before others know anything is wrong.

Litter. The kind of litter and its management are important in getting maximum results. This will be discussed in Chapter 12.

The question of built-up litter depends somewhat on climatic conditions. Generally, built-up litter saves labor and gives satisfactory results. By built-up litter, we refer to litter that has been used for six months or longer. Such litter has developed a microflora that has beneficial effects.

When built-up litter is used, only the caked and surplus litter is removed between broods and a layer of fresh litter is placed in the area where the chicks will be confined for the first week or two.

If the litter becomes heavily infested with worms it should be changed.

Disease control. Keeping the flock healthy is the most important management problem for the grower. In recent years, the development of control measures for several diseases has made this job somewhat easier, but the demands for a disease-free broiler at market time have increased the need for better and more complete control of diseases that affect the market quality of broilers. See vaccination program (Table 9–8).

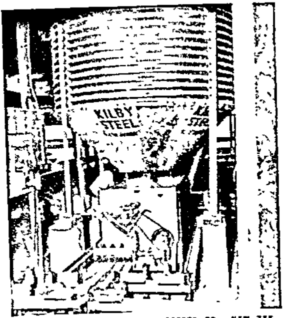
Marketing

The more general problems of marketing poultry are discussed in Chapter 11. Some of the problems related to marketing broilers will be discussed below.

Slaughtering and dressing. The methods used in killing and dressing broilers are discussed in Chapter 11. Modern equipment and improved meth-

ods have greatly reduced the labor required in dressing broilers as well as all poultry.

Processing. Broilers are sold as whole birds, halves, cut-up, parts, in chicken dinners, barbecued, etc. The consumer continues to demand food products which are ready-to-serve. He is no longer interested in purchasing a live broiler or a New York dressed bird. They must be ready-to-cook or already cooked. The broiler industry, as well as all food industries, must satisfy the demand of the consumer.



COURTESY AUTOMATIC POULTRY FEEDER CO., NEW ZEELAND, MICH.

Fig. 6–14. Bulk bin discharges feed into automatic feeder.

Ice-packed or frozen. Broilers or fryers are offered to the consumer either ice-packed or frozen, and of the two, ice-packed birds are the popular choice. The consumer considers ice-packed poultry as fresh while the frozen birds are regarded as storage or held poultry. Also, the bone discoloration associated with frozen poultry, especially in young chickens, has handicapped their sales appeal.

Consumption of broiler meat. The production of broilers has become rather uniform throughout the year, more so than the consumption of broilers, which is relatively high during the summer months and low during the late fall and winter. For many years, the failure to adjust production to consumption has resulted in low prices during the fall and winter months.

The National Broiler Council has developed an excellent program for promoting broilers in the United States, but the producers must realize there is a limit to the quantity of broiler meat that will be consumed at prices that return a profit.

Integration. It is estimated that more than 90 per cent of the broilers raised in the United States are grown under some kind of contract or integrated set-up. Feed dealers, processors, hatcherymen, and others have learned that if they planned an expansion of broiler production in their territory, they had to find a way to finance the expansion and assume some of the risk. One firm may supply the feed, hatch the chicks, finance the entire operation, process the broilers, and pay the producer for raising the broilers. There are many modifications and degrees of integrated operations.

Capon Production

The art of caponizing is exceedingly old, dating back to the pre-Christian era. As early as 37 B.C., Cato and Varro stated in their book *Roman Farm Management* that "the altered males are called capons." Reaumur in his book

The Art of Hatching and Bringing up Domestic Fouls, etc., published in A.D. 1750, mentioned the fact that capons can be trained to care for young chicks.

The caponized male as it develops takes on some of the characters of the female. The comb and wattles do not develop, and capons are less active than cockerels.

The objectives of caponizing. The principal objective of caponizing is to improve the quality of the meat produced. This is the same objective the farmer has in castrating male calves or pigs. The improvement in the quality of the meat insures a better price for capons than for cockerels which have become staggy. There is also a slight weight advantage for capons as compared to cockerels when the birds are seven or eight months old, when they are usually sold. Contrary to public opinion, capons will become tough-meated after they are more than one year old.

Breeds to caponize. Since capons are raised for meat, it is evident that only those breeds should be caponized which are efficient producers of high-quality meat.

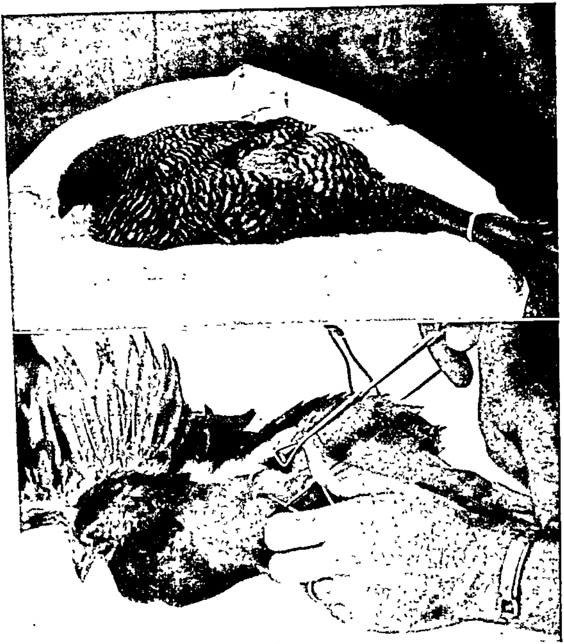
Time to caponize. The size of the cockerel is the most important consideration in deciding when to caponize. Cockerels weighing from one and one-half to two pounds are the most satisfactory size on which to operate. The operation is more successful when performed on young birds. Chicks hatched in May can be caponized in July and be ready for the market in December. June-hatched chicks can be finished as January or February capons.

Feed and water should be withheld from the cockerels twelve to eighteen hours before the operation is performed.

The operation. The most satisfactory way to learn to caponize chickens is to get instruction and experience by working with an experienced operator. A brief description of the operation will be given here for the benefit of those who desire to learn something about the operation before attempting to do the work. Birds weighing one and one-half to two pounds are about the correct size for caponizing. The bird can be held in place on a barrel head or table by weights attached to the legs and wings.

The operation is simple and almost anyone can do the work after he has had some experience. When the incision is to be made, the skin and muscles beneath the skin should be drawn toward the hip and the incision made between the last two ribs. The operator should avoid cutting any large blood vessels in the skin. The incision should be about three-fourths inch in length. Figure 6–15 shows the incision which has been made, the spreaders in place which hold the ribs apart, and the forceps being used to remove one of the testicles. The danger in the operation lies in rupturing the blood vessels which are located near the gonads. Birds which die soon after the operation should be dressed and used.

Before gaining entrance to the body cavity it is necessary to use a sharp pointed hooked-probe to tear the membranes which line the body cavity. If the incision is made at the correct location the testicles can be located easily —attached to the back at the forward end of the kidney. The size of the



COURTESY MISSOURI AGRICULTURAL EXPERIMENT STATION

Fig. 6–15. Caponizing.

gonads varies with the sexual maturity of the bird, but in birds weighing one and one-half pounds they will be only slightly larger than a grain of wheat. They are usually yellowish in color but may be grayish or black.

The experienced operator can remove both testicles through one opening, but the amateur will have best results by making an incision on each side of the body. The size of the opening should be as small as is convenient for the operator's work.

When the testicles are removed the spreader should be closed and removed from between the ribs. The skin and the muscles underlying it will find their position and form a natural bandage over the incision between the ribs.

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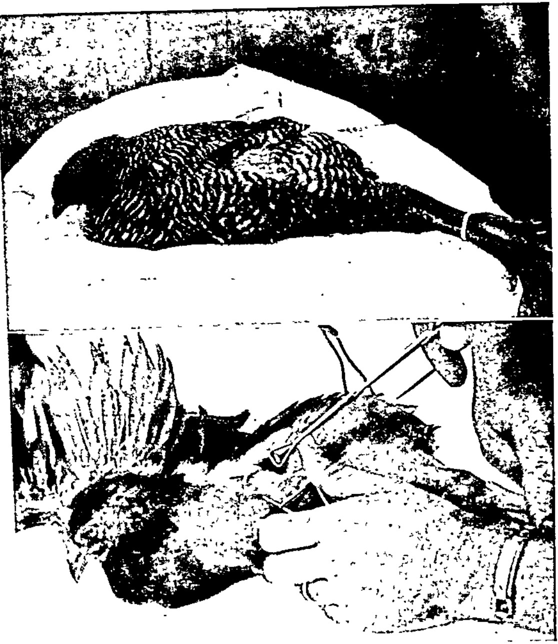

COURTESY MISSOURI AGRICULTURAL EXPERIMENT STATION

Fig. 6–15. Caponizing.

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The experienced operator can remove both testicles through one opening, but the amateur will have best results by making an incision on each side of the body. The size of the opening should be as small as is convenient for the operator's work.

When the testicles are removed the spreader should be closed and removed from between the ribs. The skin and the muscles underlying it will find their position and form a natural bandage over the incision between the ribs.

Slips. If any part of the testicle is left inside the body cavity the bird is not completely castrated. As it develops, instead of becoming a capon, it shows the characters of the cockerel and is known as a slip. Sometimes these male characters do not appear until just before the birds are ready for market, their development depending upon the amount of testicular material left in the body cavity. Slips usually command a price between that of the capon and cockerel.

Care of the birds after the operation. Soon after the operation the birds should be placed in a house without roosts where they have access to the same ration they have been receiving. They should be kept under these conditions for a week to ten days.

Wind puffs are quite common among recently caponized birds, and their occurrence need not cause any alarm or indicate faulty technique. Wind puffs are caused by air escaping from the air sacs of the abdominal cavity which were punctured by the operation; the air passing through the opening which was made between the ribs collects under the skin which has healed. The only remedy is to puncture these puffs with a sharp knife each day until they cease forming, which will usually be within two weeks after the operation.

Growth and feed consumption. Table 6–4 shows the relative size of

Table 6–4

COMPARISON OF GROWTH OF PUREBRED AND CROSSBRED CAPONS AND COCKERELS. AVERAGE WEIGHT IN GRAMS (454 GRAMS = 1 LB.) AT TWENTY-FOUR WEEKS OF AGE [4]

Strains	1935				1936			
	Capons		Cockerels		Capons		Cockerels	
	No	Wt.	No	Wt.	No.	Wt.	No.	Wt.
Barred Rocks	41	2535	43	2839	31	2739	34	2572
Rock x Reds	41	2938	39	2851	...	...	...	...
S. C. R. I. Reds	...	...	...	...	14	2504	14	2536
Red x Rocks	...	...	...	...	13	2612	14	2849
New Hampshires	...	...	...	...	29	3092	27	2917
N. H. x Rocks	...	...	...	...	12	2632	12	2662

[4] Annin and Halpin.

cockerels and capons at twenty-four weeks of age. At this time there is little difference in the size of cockerels and capons.

Feeding and management. The feeding and management of capons is not unlike that of other growing stock. They should receive a good growing mash and grain in hoppers. They should be raised on clean range where there is growing green feed and plenty of shade during the summer, and otherwise receive treatment similar to that given growing pullets.

Chemical caponizing. This process is accomplished by the implantation of the hormone diethylstilbestrol under the skin of the neck near the head or by feeding the estrogenic substance dienestroldiacetate. Injections may be

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Fig. 6–16. Administering hormone products to chickens, under the skin near the head.

in the form of pellets, paste, or liquid. Both substances are female hormones that cause the male characteristics to be suppressed, producing a carcass that contains more fat than untreated birds. These estrogens promote tenderness and juiciness of the meat and improved feathering.

Hormone treatments are given to secure maximum results when the birds are ready for market. Implantations are made four to six weeks before the birds are to be marketed. When fed, the hormone is generally incorporated at the rate of 32 milligrams per pound of feed and fed for about three weeks before the birds are marketed. Young chickens that have been treated with these hormones are marketed as caponettes.

Excessive hormone treatments may produce some undesirable side effects which should be noted by poultrymen. Water consumption may be greatly increased and excessively wet droppings become a problem. The birds may tread each other more than normally, and they appear to be less resistant to disease and to heat.

In 1959, the industry agreed at the suggestion of the U. S. Department of Health, Education and Welfare, to discontinue the use of diethylstilbestrol pellet implants until the question of tolerance of this hormone residue was resolved.

There is usually a good market for capons from November to April, with the highest prices generally prevailing after January. The general farmer sells capons as live birds to dealers. Poultrymen who produce a large number of capons may sell to dealers in a large city market or kill and dress for special outlets.

Growing Replacement Pullets

The value of a pullet as a layer or breeder depends upon her breeding and on how well she was grown.

Confinement versus range. Because of losses from predators on the range and savings in labor, many poultrymen have abandoned the range and have

COURTESY, OHIO AGRICULTURAL EXPERIMENT STATION

Fig. 6–17. Debeaking process.

established confinement rearing of pullets. Data available indicate that pullets grown on range give somewhat better results as layers than those grown in confinement, but the difference is not enough to offset the extra labor required and the risks involved with predators on the range (Table 6–5).

Floor space. More housing space is required for raising pullets in confinement than on range While one square foot or less of floor space is sufficient in range shelters for growing pullets, at least twice as much space must be allowed for pullets raised in confinement.

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Fig. 6–18. A properly debeaked bird.

Table 6–5

CONFINEMENT VS. RANGE FOR GROWING REPLACEMENT PULLETS. THREE YEARS RESULTS. MISSOURI

	Range	Confinement
No. birds	2170	2080
Losses 8–22 wks. (per cent)	6.7	7.1
Avg. wt. at 22 wks.	3.8	4.0
Avg. age at sexual maturity	177	173
Body wt. at 44 wks.	5 06	5 03
Avg. egg wt. (Mar.–Apr.)	26 2	26 0
Egg production 154–454 days (per cent)	60 9	59 1
Adult mortality (per cent)	14 2	15.0

Cannibalism. Pullets grown in confinement will have more feather picking and cannibalism than birds grown on range. As soon as these troubles appear, the pullets should be debeaked (Fig. 6–17 and 18).

Predator control. In some areas, losses on range from predators have been so heavy that poultry managers have gone to confinement raising. Predators giving most trouble are foxes, hawks, owls, dogs, cats, skunks, weasels, and raccoons.

Rats may cause heavy losses among chicks before they go to range. Every poultry farm needs an effective rat control program which includes destruction of their hiding places and the use of poisons such as warfarin.

Foxes probably cause more losses on range than any other animal. They can be trapped or hunted. An electric fence surrounding the birds on range is quite effective. The wire should be about 10 to 12 inches above ground. Weeds, grass or other materials that may short circuit this fence must be kept away from the wire.

Hawks and owls can be trapped or hunted.

Dogs and cats present a problem because they usually belong to some neighbor who should be held responsible for any losses caused by his pets.

Skunks, weasels, and raccoon will kill poultry and about the only control for them is trapping.

Range Management

The management program followed on range is important in growing out healthy pullets.

Moving to range. Pullets can be moved to range when they no longer need heat (usually from 6 to 10 weeks of age) during the spring and summer months. They should be confined to the shelters for one or two days before they are allowed outside (Fig. 6–9). If moved to shelters in cold weather, the birds should be protected by enclosing two or three sides of the shelter until they become acclimated to their new environment.

Feeding. This subject is discussed more fully in Chapter 8. The advantages and disadvantages of restricted feeding and full feeding are also discussed in the chapter on feeding.

While the pullets are confined to the shelters, the feeders and waterers must be placed inside the shelters. This equipment should be located near the entrance to the shelter for a few days, and then the feeders moved nearer the automatic waterer.

Range feeders are usually built of wood on 2″ x 4″ supports so that they are easily filled or moved (Fig. 6–6). As bulk feeding has become more popular, larger feeders are being used. Bulk feeding is being used especially for turkeys

Waterers. Running water on range saves much labor and should be used if practical to do so. A ¾″ pipe laid in a plow furrow or even on top of the ground can be used to supply water to most poultry ranges. If the use of running water is impractical, barrel waterers with a float valve attached are possibly the next best equipment to use (Fig 6–6).

Green feed. If poultry is raised on range, every effort should be made to provide growing green feed. The legumes such as ladino, alfalfa, or red clover are preferred, but blue grass or orchard grass mixed with the clovers make good range.

Disease control. Healthy pullets are necessary for profitable layers; therefore the diseases and parasites that infect or infest poultry must be prevented

or kept under control. Clean range on which no chickens have been kept or poultry manure thrown for two or more years, will provide suitable range for growing pullets.

For details of a vaccination program and other disease control measures see Chapter 9.

Housing the pullets. The pullets should be moved from range to their permanent houses when they are ready to lay. Some of the early maturing pullets may have laid a few eggs. The pullets should be handled carefully with precautions taken to prevent smothering while catching or moving them. The culls should be sent to market. Debeaking is advisable under most conditions. If the birds are to be vaccinated near this age (16–22 weeks), it should be done when the birds are moved. Care should be taken to insure that pullets take to the roosts in their laying quarters and do not pile up and smother. When only a few hundred pullets are raised, they may be caught and moved at night with a minimum of disturbance to the birds.

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Chapter 7

Housing Principles and Practices

POULTRY IS HOUSED for comfort, protection, efficient production, and for the convenience of the poultryman.

The chicken, as a wild jungle fowl, sought safety and rest on the high limb of a tree or in the thick underbrush. The jungle served as protection against the hot sunlight. The bird tucked its head under its wing and drew its feet up under its body and was well protected against cold by its covering of feathers.

Chickens reproduce best in the spring when the weather is neither too hot nor too cold. In order to secure better growth and egg production during other seasons of the year, it is desirable to provide spring-like housing conditions.

Location of Poultry House

In planning a poultry house, one should provide space for expansion in length of the present house and/or location for additional buildings. The tendency in poultry production is toward total confinement, less range, and larger flocks.

Location of the house should be on ground high enough to provide good drainage and protection against the danger of floods. The house should be easily accessible from a road for delivery of feed and removal of litter. It should also be conveniently located for care of the flock. Several daily trips are necessary for gathering eggs and care of the birds

Poultry houses should generally face south or southeast to receive the greatest amount of sunshine during the winter, however, this is recommended only if large windows are used. If the arrangement would give an awkward and unattractive appearance or if the prevailing winds would blow against the front of the house, it should be faced differently.

Housing Requirements

A poultry house should be designed so that it may be easily adapted for the brooding, rearing, or laying flock. There is a tendency to start chicks in a house and leave them there until sold as layers. Moving the birds requires more labor and creates stress in the flock. Some poultrymen find it desirable

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Fig. 7–1. Solar house.

to move the brooding and rearing equipment. Houses must be kept in use most of the time to reduce the housing overhead costs. Brooding and rearing facilities must also be kept in use with succeeding broods or used part of the time for laying stock.

Birds must be comfortably housed in order to produce well. They need adequate room in the house, a moderate temperature, sufficient air space and ventilation to prevent "stuffiness" in the house, dry living quarters, and light.

Floor space. The floor space that should be provided per bird will depend on such factors as type of floor, size of bird, temperature, and ventilation. Overcrowded birds do not grow or lay normally and their feed conversion is poor. Crowded conditions cause birds to develop faults such as picking, feather eating, and cannibalism.

Batteries (Fig. 6–7), tier arrangement of cages (Fig. 7–29), tier perches, overdropping pits (Fig. 7–1), and slatted or wire floors (Table 7–9), permit housing a greater number of birds in a given floor space. However, the additional cost of equipment and labor may not be justified because of its questionable economic value.

Floor space requirements for growing poultry have been studied by a number of investigators. It is customary to start chicks in a given location and provide enough space to meet their requirements until they are marketed at eight to ten weeks of age. The data indicates (Table 7–1), that broilers do better if floor space provided is up to one square foot per bird. Chicks may be started with as little as six to ten square inches of space per

Table 7–1

INFLUENCE OF FLOOR SPACE PER BROILER ON GROWTH [1]

Observation	Floor Space per Broiler			
	Summer Test (75 Days)		Fall Test (70 Days)	
	0.75 sq. ft.	1.0 sq. ft.	0.75 sq. ft.	1.0 sq. ft.
Ave. weight. Pounds	2.37	2.44	2.57	2.75
Mortality, per cent	7.7	8.2	2.9	2.5
Pounds of feed per pound of gain	2.92	2.93	2.81	3.05
Receipts per sq. ft. of floor space	$0.99	0.78	0.94	0.75

[1] Oklahoma Agr'. Exp. Sta. Bul. B-402.

bird. Then, during the first five or six weeks, the space is increased about ten inches per week. Thereafter, 20 square inches per week are added for each broiler or replacement pullet until each has 144 square inches of space (Table 7–2). Some poultrymen provide the additional space as it is required rather than to make it all available at the beginning. This practice gives more efficient use of floor space.

Table 7–2

FLOOR SPACE REQUIREMENTS AND AGE OF BROILERS OR REPLACEMENT STOCK

Age in weeks	Floor space per bird
1	10 sq. in.
2	20
3	30
4	40
5	50
6	70
7	90
8	110
9	130
10	150

Floor space requirements for laying hens have not been adequately studied under controlled (temperature and ventilation) environmental conditions. In unheated and gravity ventilated poultry houses, it has been the practice to provide about three square feet of floor space per hen for Leghorns or other light breed chickens and four square feet for general purpose or meat type hens. Where fan ventilation and artificial heat are used, and the droppings are removed every day or so (pit cleaners), the floor space may be reduced 50 per cent or more, especially for the light breeds (Fig. 7–1 and Table 7–3).

Pen space or size of pens is not as important as once believed. It is not uncommon to brood 5,000 to 20,000 chickens or to keep 1,000 to 5,000 hens in a single pen. Building large pens reduces housing costs and especially labor

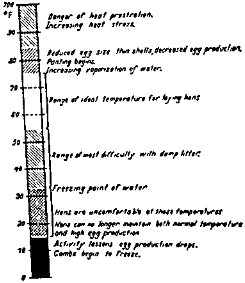

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Fig. 7–2. Influence of house temperature on laying hens.

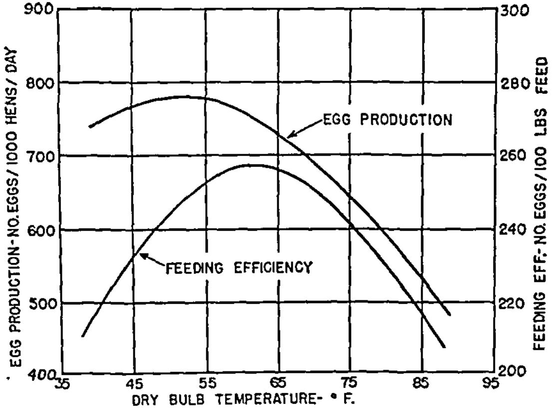
costs in caring for the birds and gathering the eggs. Birds of different ages should not be housed together in the same pens. Harmful habits may start in a pen and spread rapidly, and it may be advisable to keep the birds in smaller pens. However, it appears that the saving in labor with the use of large pens outweighs the disadvantages that might arise.

Temperature. Birds can tolerate wide extremes of temperature (approximately 50 to 110° F.) depending on age, feathering, and access to water. Feathers are good insulation against cold weather. Evaporation of moisture in the air sacs (p. 52) helps to keep the body temperature normal in hot weather. However, for maximum growth, egg production, and efficient use of feed, the optimum temperature in poultry houses is rather narrow (50 to 90° F.) depending on the age of the birds.

Temperature requirements for growing chickens have been discussed in chapter 6 and are shown graphically in Fig. 6–1. An inexpensive source of heat (hot water or hot air) is generally used to meet the heat requirements of fully feathered birds (8 to 12 weeks and older). Thermostatically controlled heating equipment, covered brooders (Fig. 6–8), or use of chick guards to hold the chicks close to the heat pipes, provide the additional heat required during the early growing period (zero to eight weeks). With slight modification, or use of additional equipment, a laying house may be used for brooding young chicks or rearing pullets. Chicks should be started at 90 to 95° F. and the temperature should be lowered about 5° F. per week until a temperature of 65 or 70° F. is reached. This temperature is satisfactory for finishing broilers or growing replacement pullets from about eight weeks until sexual maturity.

The temperature requirement for laying hens to give maximum egg production is about 55° F. (Table 7–4 and Fig. 7–2 and 3). Birds eat more feed and lay fewer eggs during cold weather. The warmer the temperature, the less feed they eat, but as the temperature rises above 55° F., their egg production declines in number and size. Mature chickens suffer more from extreme warm weather (death from heat exhaustion) than from extreme cold weather. A mature bird will seldom freeze to death. However, some die from heat prostration when the temperature reaches 100° F. or more. Birds kept in cold quarters do not move about or eat and drink normally and egg production declines as does the fertility of the eggs.

Temperature is closely allied with ventilation (p. 187) and moisture (p. 189) in poultry houses. Optimum temperature conditions in poultry



PURDUE EXT. SERVICE LEAFLET (378)

Fig. 7–3. Note the effect of temperature on the feeding efficiency and egg production of laying hens. Egg production drops off rather sharply past 55° F. Feeding efficiency hits its peak between 55° and 60° F.

houses may be realized without the use of artificial heat by: (1) avoiding excess head room (air space), (2) keeping the house filled to capacity to take advantage of the heat production of the birds (p. 238), and (3) good insulation of the house to prevent heat loss in winter and to give cooler ceilings in summer (Fig. 7–15). The use of a solar type house may also be used to take advantage of the sun for heating (Fig. 7–1).

Ventilation. Ventilation in the poultry house is necessary to provide the birds with fresh air and to carry off moisture. It needs to be provided without exposing the birds to drafts.

Since the fowl is a small animal with a rapid metabolism, its air require-

Table 7–3

INFLUENCE OF FLOOR SPACE PER LAYER ON PERFORMANCE AND INCOME [2]

Observation	Floor Space per Layer (sq ft)		
	1.5	2.5	3.5
Egg production, %	60	61	62
Mortality, %	15.7	15	14.3
Egg income per bird	$ 1.66	1.69	1.73
Egg income per sq. ft. of floor space	$ 1.10	0.68	0.49
Total egg income per pen	$275.40	169.28	122.76

[2] Nordskog.

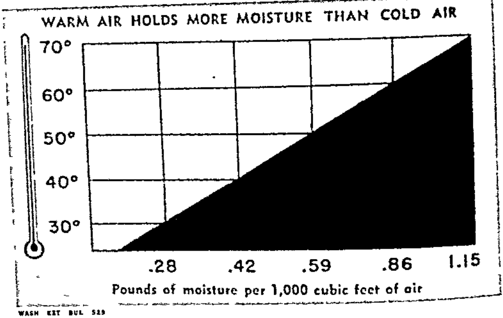


Fig. 7–4. Influence of air temperature on its water holding capacity.

ment per unit of body weight is high in comparison with that of other animals (Table 7–5). A hen weighing 4.5 pounds, and on full feed, produces about 52 liters of CO_2 every 24 hours. Since the CO_2 content of expired air is about 3.5 per cent, the total air breathed amounts to 0.2 liters per pound live weight per minute.

The amount of air space needed per bird will vary with the rate of movement of the air. The greater the difference between the inside and outside temperature of a house, the greater the movement of air between the inside and outside. A house that is tall enough for the attendant to move around in comfortably will supply far more air space than will be required by the birds that can be accommodated in the given floor space.

In providing ventilation, drafts should be avoided as they make birds susceptible to colds, roup, and bronchitis.

Exchange of air between the inside and outside of the house will help to

Table 7–4

INFLUENCE OF HOUSING TEMPERATURES ON EGG PRODUCTION AND FEED CONSUMPTION [3]

Air Temperatures	Egg Production	Egg Size Oz. Doz.	Daily Feed Per 100 Hens	Feed Per Dozen Eggs
23° F.	26 per cent	24.2	41 pounds	19.0 pounds
37	65	23.9	35	6.5
45	74	23 8	33	5.4
55	78	23.5	31	4.8
65	75	23.2	29	4 6
75	68	22.7	27	4.8
85	56	22.1	25	5.4

[3] U. S D A. Misc. Pub 728.

Table 7–5

ESTIMATED AIR CONSUMPTION OF DIFFERENT ANIMALS [4]

Species of Animal	Liters of Air per Pound of Weight per Minute
Man	0.045
Goat	0.090
Rabbit	0.180
Chicken	0.225
Guinea pig	0.270

[4] Mitchell and Kelly.

keep the pens dry. One hundred, five-pound hens will eliminate about 36 pounds of water per day at 30° F., 42 pounds at the ideal temperature of 55° F., and as much as 50 pounds at 80° F. About 80 per cent of the water excreted is by way of droppings and 20 per cent by respiration. This amount, plus the spillage around drinking vessels, adds up to five or six gallons of water that should be removed from the house daily if the birds are to be kept in good production.

Winter ventilation requirements will be determined largely by the amount of water to be removed and the house temperature. Water has to be vaporized before removal by ventilation and this requires heat. Approximately 1,000 B.T.U.'s (British Thermal Units) are required to vaporize one pound of water. The heat necessary to vaporize the water may come from several sources. These include: (1) body heat of the birds (90,000 to 140,000 B.T.U.'s per 100 hens per day), (2) decomposition of litter, (3) heat from the sun on windows or roof, (4) heat from the ground when the inside temperature is below that of the ground, and (5) supplemental heat from a heating system. It is evident that a house should be well insulated to conserve heat for moisture vaporization (Fig. 7–4) and that fans should work satisfactorily for removal of moisture. Table 7–6 gives recommended air flow rates for winter housing where an inside temperature of 50 to 55° F. is maintained. The size of fan to be installed for year-round operation will probably be determined by the needs for summer ventilation.

Summer ventilation is used to remove heat when the temperature rises above 70–80° F. in the laying house. Moisture removal is usually not a problem in summer because of the increased capacity of warm air to hold water (Fig. 7–4). It has been recommended that an air flow rate of 1.2 to 1.5 cubic feet of air per minute per pound weight of birds be provided for summer ventilation. During hot summer weather, a 1000-bird flock of four-pound hens would require a fan capacity of 6,000 c.f.m. (cubic feet per minute) at ⅛ inch static pressure. An even distribution of air flow could be obtained by the installation of two or three small fans rather than a single large one.

Moisture. Optimum humidity in poultry houses has not been adequately determined. It should range between 45 and 75 per cent relative humidity. This range gives a wet bulb reading of 45 to 50° F. at 55° F., the optimum temperature for laying hens.

Table 7–6

RECOMMENDED AIR FLOW RATES FOR WINTER HOUSING [5]

Outside Temperature	Cubic Feet of Air per Minute per Pound of Live Weight
0–15° F.	0.2
15–28	0.4
28–40	0.6
40–50	0.7
50–60	0.85

[5] Roller, et al. Purdue Ext. Leaflet 378.

Table 7–7

THE EFFECT OF HOUSING ON LITTER MOISTURE AND EGG CLEANLINESS [6]

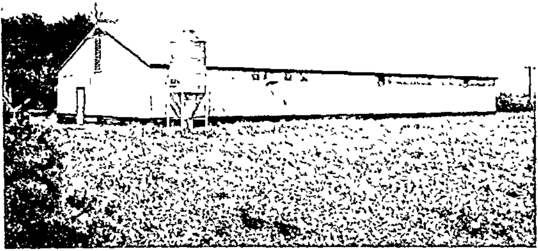
House	Moisture of Litter	Soiled Eggs	
		Slightly	Dirty
	per cent	per cent	per cent
A	28.3	6.4	1.6
B	50.3	31.5	18.8
C	44.0	40.7	4.6
D	34.0	26.4	3.1

[6] Walker and Bressler.

Dryness may cause dusty litter in the poultry house resulting in respiratory or eye troubles among the birds. A house that is too dry may also cause poor feather growth or condition, an itchy skin, scratching, and faults such as feather eating, picking, or cannibalism. Houses are more likely to become too dry in hot weather than during other seasons.

Dampness causes wet litter, soiled plumage, breast blisters, excessive amounts of ammonia liberation from the droppings, and a higher percentage of soiled eggs in laying houses (Table 7–7). Dampness furthers coccidia sporulation, worm egg incubation, growth of bacteria, and may result in disease problems if the condition persists. During cold weather, dampness becomes a problem in unheated and gravity ventilated poultry houses. Warming the air (Fig. 7–4) and moving it out (Table 7–6) removes moisture and results in a dryer house.

Deep litter on the floor will prevent warm, moisture laden air exhaled by the birds from condensing on the floor. Proper insulation of the ceiling and sidewalls will keep the inner surface warmer and will reduce condensation on these surfaces. Gravity (Fig. 7–22) or forced ventilation by use of intake or exhaust fans (Fig. 7–23), will remove much of the moisture laden air. Removal of droppings every day or so, when a pit cleaner is available, will also remove much moisture from the house.



COURTESY DOANE AGRICULTURAL SERVICE, ST LOUIS 8, MO.

Fig. 7–5. Windowless house for controlled lighting.

Light. Birds require light for normal moving about and for eating and drinking. Light also aids in stimulating and controlling egg production.

Daylight is generally used to supply the source of light. Most houses are provided with windows which may be opened or closed to aid ventilation. Since there is greater heat loss through a single pane of window glass than through an insulated wall, the trend has been to reduce the amount of window space. Approximately one square foot of window space for each 25 to 40 square feet of floor space is recommended for general type poultry houses. The windows are generally placed on both sides of the house for more equal distribution of light and for cross ventilation in summer.

Thermopane windows used in solar houses have double panes with an air space between them (Fig. 7–1). These houses have large windows and are faced south in order to take advantage of the winter sun.

Artificial light is being used in place of daylight by some poultrymen for growth of pullets and egg production. It is less variable than natural daylight and has been used as a supplement to normal daylight in fall and winter to increase winter egg production. The light stimulates the birds to produce more eggs and provides them with a longer period to eat and drink. A 20-watt bulb for each 100 square-feet of floor space is sufficient.

Windowless houses are used to some extent for growing broilers and egg production (Fig. 7–5). They are easier to keep warm in winter but more difficult to ventilate in summer. One must rely on electricity and fans for lighting and ventilation. This adds 10–30 cents to the housing cost per layer per year.

Controlled lighting (stimulighting) is used to secure increased pullet year egg production and to bring turkey breeding hens into production at seasons other than spring. Pullet replacement chicks are raised in darkened (windowless) houses to 20 weeks of age with six hours of artificial light per day (Fig. 7–5). The light is then increased about 18 minutes per day each

Table 7–8

EFFECT OF RESTRICTING LIGHT DURING GROWING PERIOD AND INCREASING LIGHT WEEKLY DURING LAYING PERIOD [7]

Observation	Lighting Schedule During Laying Period	
	18 minute increases	14 hours per day
Egg production per hen per year	270	237
Mortality, per cent	16 6	13.3
Feed per dozen eggs, pounds	3.6	3.6

[7] King

week during the first laying year. The system results in greater egg production as compared to birds raised on a 12-hour day whose day has been increased to 14 hours after they had been in production for a time (Table 7–8).

Kinds of Poultry Houses

Poultry houses are classified in several different ways. These include size, portability, purpose, style, and type of construction.

Sizes of houses. Houses vary in size, depending on the number of birds to be housed and the size of units in which they are to be kept (Fig. 7–6).

Colony houses are one-room buildings intended for housing single flocks or colonies of birds. They are usually some distance from each other on range.

Multiple-unit houses are long houses consisting of several rooms. Each room is like every other room and is known as a pen. In fact, a multiple-unit house is essentially several colony houses built into a single structure.

Multiple-story houses consist of two or more stories. They are popular on large commercial poultry farms where it would be impractical to provide range. Multiple-story houses require less ground, less roofing, and are easier to heat than multiple-unit houses. On the other hand, they require heavier timbers for construction, increased labor in getting materials to the upper floors, and are more difficult to ventilate.

Portability of houses. Houses may be constructed so that they are movable or so that they must remain in one place.

Portable houses are small one-room colony houses that are built on runners or skids so that they may be moved from place to place. By moving the houses from place to place, clean green range may be provided. Portable houses are generally used for brooding chicks.

Permanent houses are built on a permanent foundation and are, therefore, immovable. They usually have cement floors. Permanent houses are generally multiple-unit or multiple-story houses.

Purpose of houses. Houses are constructed for several purposes on the poultry farm.

Brooder houses are used for brooding chicks. Colony houses are used for this purpose on general farms and breeding farms. These houses are generally 10 to 12 feet wide and 12 feet deep. The houses may be moved from

place to place to provide clean grass range. Where several colony houses are scattered over a range, much labor is required in caring for the birds.

Multiple-unit brooder houses are used on large commercial farms. The pens are close together and often a centralized heating plant is used. These factors reduce the labor required for caring for the birds. Range is generally not provided because it soon becomes contaminated, since the buildings are immovable.

Rearing houses are used to shelter the chicks from the time they no longer need brooder heat until they are placed in the laying house. This period will vary from two to four months, depending on the season of year and the breed of chickens. Colony and multiple-unit brooder houses are often used for this purpose. Range shelters (Fig. 6–9) are popular for housing pullets on range after they no longer need heat. The colony houses generally contain more pullets than can be cared for comfortably as they approach maturity. The range shelters make it possible to separate the birds in smaller groups.

Laying houses hold the laying hens. They vary all the way from one-room colony houses to multiple-story houses (Fig. 7–6). Instead of being provided with brooding equipment, they are provided with nests and equipment more suitable for older birds. Laying houses also serve for breeding houses. If pen matings are used, smaller pens are made in the laying house, or the breeders are kept in separate small houses.

Styles of poultry houses. The style of the poultry house makes little difference as long as the comfort of the birds is provided. There are several styles of poultry houses with reference to types of roofs (Fig. 7–6).

Shed-type houses have single-pitch roofs. They are the simplest style of poultry house construction and require the least lumber for a given floor space. Shed-type poultry houses are the most popular type among poultrymen.

Gable-type houses require more material and labor for construction. They are suitable for straw-loft type of construction. Some poultrymen put a ceiling floor in gable roof houses and use the space in the gable for storage. Multiple-story houses often have gable roofs.

Types of construction. Several different types of building materials are used in constructing poultry houses. These include wood, hollow tile, concrete blocks, and metal (Fig. 7–7).

Wood houses are most popular because of ease of construction and general availability of building material. The outside wall is generally drop siding. There is considerable heat loss through single wall wood construction. The use of sheathing or insulation board on the inside, to provide double wall construction, greatly reduces the heat loss. Wood houses require frequent painting.

Hollow tile houses are popular in areas where tile is produced at small cost. The heat loss through hollow tile walls is less than through single wall wood construction. The tile is durable, the outside does not require paint, no inside insulation is used, the walls are ratproof, and the house is fireproof.

Concrete block houses are not widely used because they are costly and permit considerable heat loss through the walls. Some houses are built of lighter blocks made of cinders and concrete.

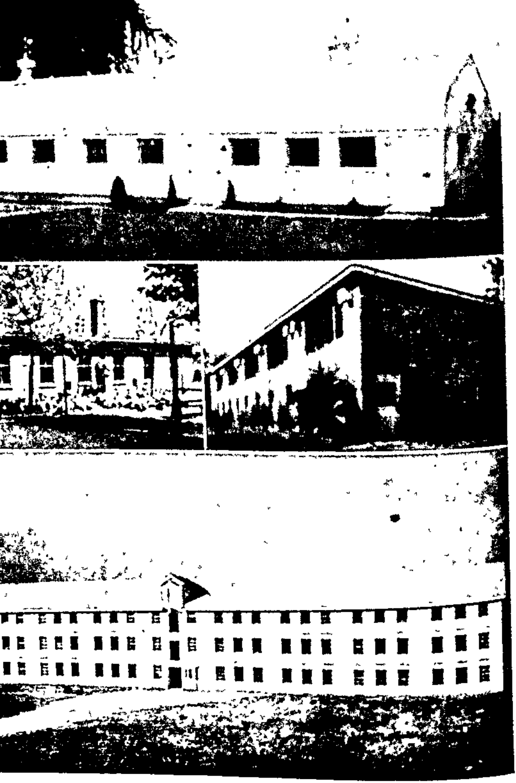


Fig. 7–6. Some types of poultry-house construction. Top, metal. (James Manufacturing Company) Center left, concrete blocks. (Portland Cement Company) Center right, tile. (U. S. D. A.) Bottom, wood. (U. S. D. A.)

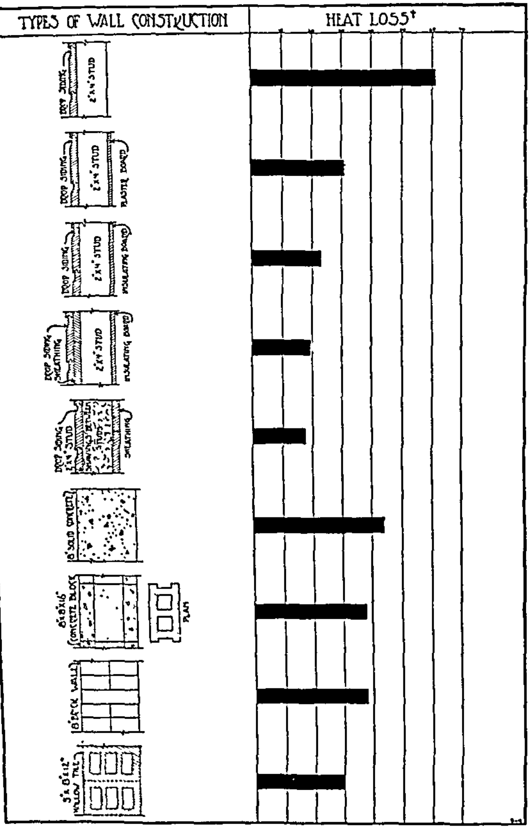


Fig. 7-7. Heat loss through different types of wall construction. The use of sheathing on the inside of the studs, with the spaces between the studs filled with shavings, as shown above, provides one of the best methods of practical insulation for poultry houses. (Ohio Agriculture Extension Service.)

Metal houses are sold by some commercial firms. The single-wall houses are difficult to keep warm during winter. Some have double wall construction and insulation material between the walls. Metal houses are expensive but durable and easy to keep clean.

House Construction

There are many different kinds, sizes, and types of poultry houses. Any one of them may be expected to prove satisfactory as long as housing requirements (p. 183) are followed in their planning, construction, and operation.

Width. Poultry house width is generally between 30–40 feet for efficiency in ventilation and economy in cost. Houses more than 40 feet wide are difficult to ventilate, while a narrow house requires more wall space. For instance, to provide 2,000 square feet of floor space in a house 20 feet wide, will require a length of 100 feet or a total of 240 feet of sidewall. If the house is 40 feet wide, it will be 50 feet long and will require 180 feet of sidewall.

The foundation. Most permanent poultry houses have concrete foundations and floors. They are durable, ratproof, and easily cleaned. Before starting to dig the ditch for the foundation, square the corners by fixing one side of the site of the proposed house. With this as a base, locate the other corner posts by using the 6-, 8-, and 10-foot combination, measuring 6 feet from one end of the fixed line and 8 feet from the same line at right angles. The angle between the two lines is fixed by measuring 10 feet from the 6-foot mark of the fixed line to the end of the 8-foot line, thereby making a square corner.

The depth at which the ditch should be dug for the foundation for the walls will depend upon the height of the house and the dangers of heaving as a result of freezing. Generally, the foundation should be at least 6 inches thick, and extend about 18 inches below the surface of the ground. If the soil is firm and does not cave in, it will not be necessary to build a form beneath the surface of the ground. The top of the foundation wall should extend at least 12 inches above the ground level (Fig. 7–8).

The concrete mixture should be a 1:2½:3½ mixture with 5 to 6½ gallons of water per sack of cement.

The floor. The top of the concrete floor should be at least 10 inches above the outside ground level. The space inside the foundation and beneath the floor should be built up about 8 inches above the outside ground level with gravel covered with cinders, and well tamped. A layer of tar paper may be placed on top of the cinders before the concrete is poured in order to further inhibit the possible capillary rise of water through the floor.

The concrete floor should be sloped to a floor drain in the middle of the house. The layer of concrete should be 2 to 3 inches thick. The cement mixture consists of a 1:2:3 mixture with 4½ to 5½ gallons of water per sack of cement. The entire thickness of the floor may be poured at one time. The top of the floor should be finished with a wooden trowel in order to produce a smooth surface, and the finish should be made with a light trowel. The floor

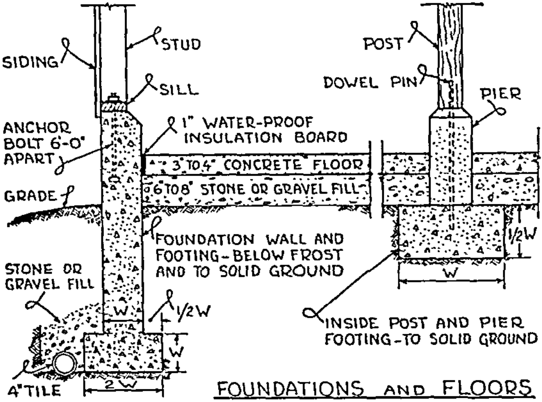


Fig. 7–8. Foundation and floor.

should be kept wet for several days after being laid in order to permit the concrete to harden without cracking.

A floor for a 36′ x 100′ house will require about 16¼ cubic yards of concrete, consisting of the following:

Portland cement..................	112 sacks
Sand (fine aggregate)..............	8¾ cubic yards
Stone (coarse aggregate)...........	12½ cubic yards

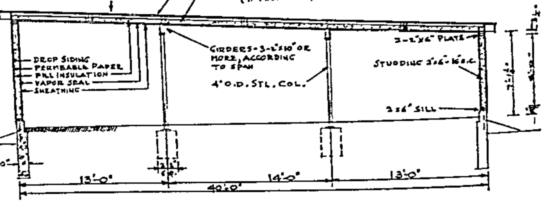
The concrete floor may be omitted if drainage is good and deep compost litter is used. A dirt floor is warmer (Fig. 7–14).

The framework. The sills are usually 2 x 4 inches, laid on the broad side and bolted to the concrete foundation by bolts inserted in the concrete foundation at the time it was poured. Heavier sills are used for multiple-story houses. Sometimes two 2 x 4's are spiked together for sills.

Runners, 3 x 4 or 4 x 6 *inches in size* are used as sills for portable houses. Portable houses that are to be moved on runners must be braced extra well in the corners to stand the strain of moving.

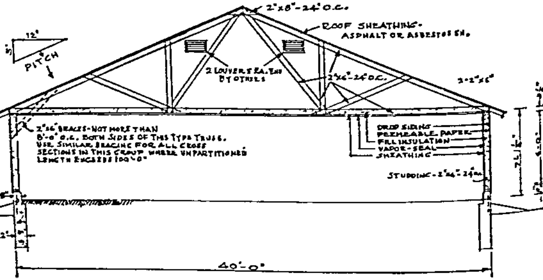
Joists for wooden floors are either 2 x 4 or 2 x 6 inches, depending on the span. They should be 16 to 20 inches apart. If the space is over 10 feet, a center support should be used for 2 x 4-inch joists.

Studdings are 2 x 4 inches and spaced 2 to 4 feet apart and to fit windows and doors wherever necessary. They are toe-nailed on the sill and should be set plumb with a spirit level and braced well until sheathed. The corner studs are generally doubled, making them 4 x 4 inches.



COURTESY JAMES MFG. CO. FORT ATKINSON, WISC.

Fig. 7–9. Shed type roof style.



COURTESY JAMES MFG. CO.

Fig. 7–10. Goble type roof style.

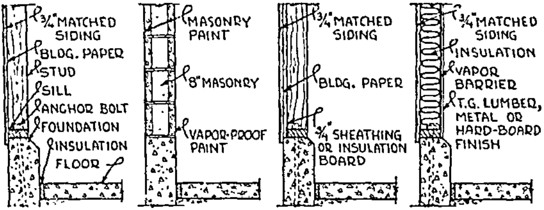
Plates are 2 x 4 inches laid flat on top of the studding. They are halved or spliced and nailed together at the ends or over a post or stud. The plates are spiked to the top of the studding. Sometimes 4 x 4 plates are used. They are made by spiking two 2 x 4's together.

Rafters are 2 x 4 or 2 x 8 inches, depending on the size of the building. Larger rafters should be used where the clear span is 12 feet or more, or in climates where the roof must support much snow. The rafters are generally spaced 2 feet apart.

Girders are 2 x 6's or 2 x 8's set on edge on posts to support the roof. They are placed lengthwise of the house and about midway of the length of the rafters, which rest on them (Fig. 7–9).

About 3,500 B.M. feet of lumber are required for the framework of a 36 x 100 foot laying house.

Walls and partitions. The walls in shed-type houses are usually constructed 6 feet high in the rear and 8 feet high in the front (Fig. 7–9). Gable roof houses are 7 feet high in both front and rear (Fig. 7–10). Sufficient head room is needed to move about in the house comfortably even when deep litter is used, yet no more headroom should be provided than needed



COURTESY OHIO AGR. EXT. SV.

Fig. 7–11. Types of wall construction.

because of the greater space to be heated in winter. Wood or block construction with insulation is generally recommended for cool climates (Fig. 7–7). The inside wall should be of wood or hard (asbestos) board construction. Metal is likely to rust and soft insulation board may be picked by chickens or become wet and buckle.

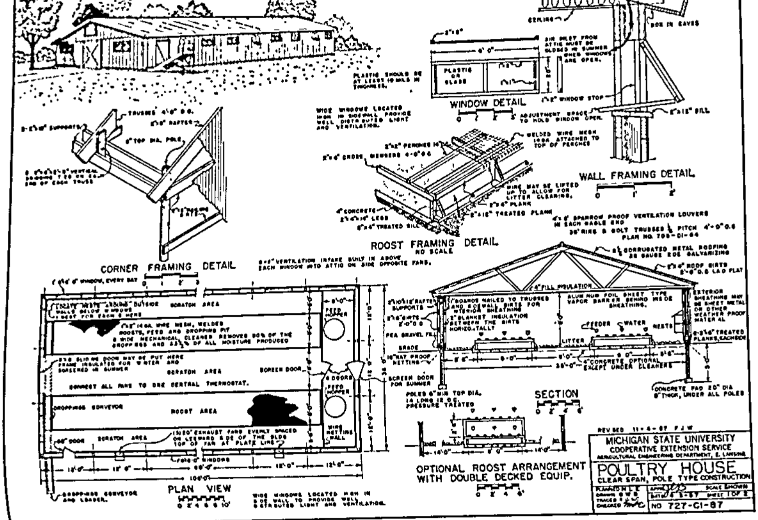
Insulation is used to conserve heat in winter and to keep it out in summer. Double wall construction is used for wood houses (Fig. 7–7). The space between the walls should be filled with some fine material such as sawdust, shavings, ground corn cobs, or commercial insulating materials. Block walls provide more insulation than single wall board but not as much as double wall construction.

Vapor barrier material is needed on the inside wall between the sheathing and the insulation (Fig. 7–11). This prevents condensation of moisture from the inside air which wets the insulation, reduces its insulating value, and eventually causes rotting of the wall. Shiny asphalt-impregnated and asphalt-coated paper, 55-pound roll roofing, aluminum foil, or two coats of asphalt or aluminum-flake paint, applied on an unbroken surface are satisfactory vapor barriers. Some commercial insulation materials have a vapor barrier attached. Manufacturers' instructions should be followed in applying the barrier, and care should be taken to avoid tearing holes in it.

Outside wall vents should be provided in wood walls to permit the escape of any moisture that gets into the insulation. These may be small openings in the outer wall, screened and protected. Moisture collecting in the insulation, is often responsible for peeling of paint from the outside walls of the poultry house.

Partitions may be made of wire, with wood or hard asbestos board extending up about 2 feet from the floor. This will prevent distraction by birds in adjacent pens and permit good circulation of air. Partitions may be made in removable panels to facilitate changing the size of pens according to management needs. Pens may be needed in a house to separate birds of different ages, sexes, breeds, matings, etc. The fewer partitions used in a house, the cheaper the cost and the less labor required in caring for the birds.

Windows. Windows are used in poultry houses to admit daylight and aid



MICH. AGR. EXP. STA. FARM BLDG. SERIES CIRC. 736

Fig. 7-12. A gable roof house for 2000 layers.

in ventilation. If artificial light and fan ventilation are used exclusively as in controlled lighting (p. 191), windows may be eliminated (Fig. 7–5). On the other hand, if windows are used to aid in heating the house (p. 191), the south side of the house should have double (thermopane) windows (Fig. 7–1).

Most poultry houses are provided with about one square foot of window space for each 20 to 40 square feet of floor space. Usually one row–three pane or two row–six pane windows are located on both sides of the house, near the top, for even distribution of light and for cross ventilation in summer (Fig. 7–12). The windows should be easy to open and close and should tilt back or be constructed for pushing to one side. The window opening should be covered with hardware cloth to prevent birds from gaining entrance.

The roof. The kinds of roofing most generally used on poultry houses are the so-called "prepared roofing," built-up roofing, metal roofing, and shingles.

Prepared roofing which is available in rolls of different degrees of thickness is widely used on poultry buildings. It is cheap and easily put on. However, it soon becomes loose, strips blow off, and it has to be replaced often. Sheathing is first put on the rafters, the roofing is tacked to the sheathing with large-headed nails, the seams overlapped, and the surfaces cemented together. The thicker the roofing material, other things being equal, the better the product. When the doors or windows are open and the wind blows, some pressure is built up in the house. The wind gets under the roof through cracks and holes in the sheathing, the nailheads are loosened, and strips of roofing are blown off after a year or so. Good grade tongue-and-groove sheathing should be used to prevent this trouble. Prepared roofing will also fit tighter if it is put on during warm weather.

Ceiling insulation is more important than sidewall insulation to prevent heat loss in winter and the entrance of heat from hot roofs in summer (Fig. 7–14). The same type of insulation may be used for ceilings as for sidewalls.

Built-up roofing consists of several layers of roofing paper and asphalt over wood sheathing. The sheathing should be of tongue-and-groove boards to prevent the wind from blowing through from the underside to loosen the roof. The first weight of roofing paper which should weigh sixty pounds per square, is laid on the sheathing and nailed down tightly with the cap spacing nails. The other layers of roofing paper, varying from two to four in number, are laid horizontal with the sheathing and cemented down with hot asphalt (Fig. 7–13).

A built-up roof costs no more than a heavy-ply prepared roofing, but lasts much longer. Some poultrymen experience difficulty in applying the asphalt and for that reason prefer one of the other types of roofing.

Metal roofing for poultry houses is increasing in popularity. It is durable and will last for years before an application of paint is necessary. The rafters need to be lathed to hold the roofing but do not need to be sheathed. This reduces the amount of lumber required.

Modern metal roofing has a double crimped edge. The crimps of one sheet fit over those of the next one. This prevents water from getting through the

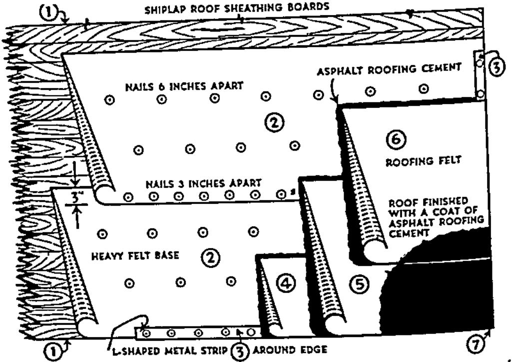


Fig. 7–13. This diagram shows the manner in which a built-up roof is applied to a board roof (1). The felt base (2) is applied to the sheathing and the edges are protected with a strip of metal. (3) Roofing (4, 5, 6) is applied and asphalt (7) is then applied over the entire roof. (Ohio Extension Bulletin 94).

roof by capillary attraction. Metal roofs do not require a steep slope to prevent leakage. They may be used on shed-type as well as gable-type houses.

Metal roofs do not make the house hotter than other forms of roofs and do not cause condensation of moisture, if the ceiling is insulated. Since heat loss is greater through the ceiling, the insulation should be thicker. In a shed-roof house, an air space should be provided with openings between the insulation and the roof (Fig. 7–15). An attic with louvers serves this purpose in gable roof houses (Fig. 7–10).

Laying-House Equipment

Good laying-house equipment is essential for satisfactory production. It should be simple in construction, movable, and easily cleaned. The perches, nests, feeders, and waterers are of particular importance.

Perches. Perches are desirable for chickens but not for waterfowl for prevention of soilage of feathers by the droppings. They should be as far away as possible from probable drafts (Fig. 7–16).

The perch poles should be spaced about 14 or 15 inches apart and made of 2 x 2-inch material with rounded tops. Heavy 1½-inch poultry netting or a 2" x 4" welded wire should be tacked on the underside of the perch section. This will prevent the birds from coming in contact with the droppings. The perch sections should be in 5- to 6-foot sections and not more than 5 or 6

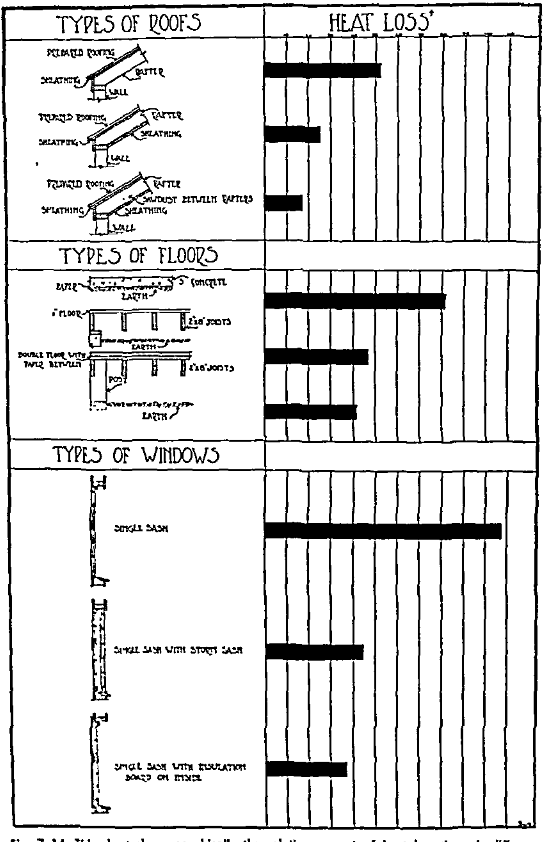
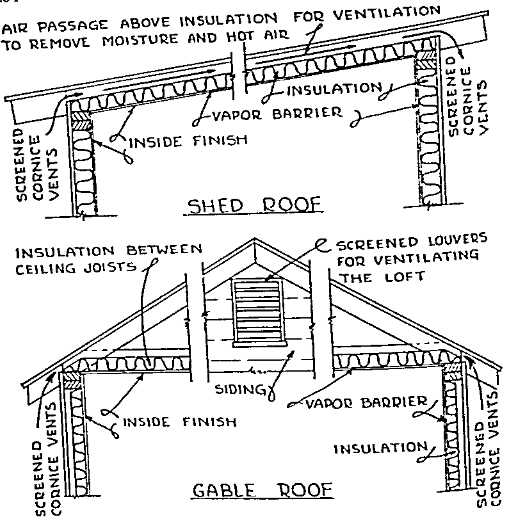


Fig. 7-14. This chart shows graphically the relative amount of heat loss through different types of ceiling or roof construction, through floors, and through different window arrangements. (Ohio Agricultural Extension Service.)



OHIO AGRICULTURAL EXTENSION SERVICE

Fig. 7–15. Ceiling insulation for shed and gable roof houses.

perches wide, for ease in handling. Some poultrymen prefer to have the perch poles at right angles to the front of the house. The facing of the perches is of minor importance. Sufficient perch space should be provided for 8 to 10 inches per bird.

Dropping pits. Dropping pits catch the droppings on the floor beneath the perches (Figs. 7–1 and 16). The perches are about 18 to 24 inches high at the rear and 12 to 18 inches high at the front. The front of the perch section rests on a board which keeps the birds from getting in the pit beneath the perches. In some houses the feeders and waterers are placed over the perches. The more time the birds spend on the perches eating, drinking, and roosting (sleeping), the greater the total percentage of droppings that will fall in the pit and the longer the remainder of the litter will stay dry and in good condition. Removal of droppings every few days by a pit cleaner or other means will remove much moisture and aid materially in keeping the house dry (p. 190).

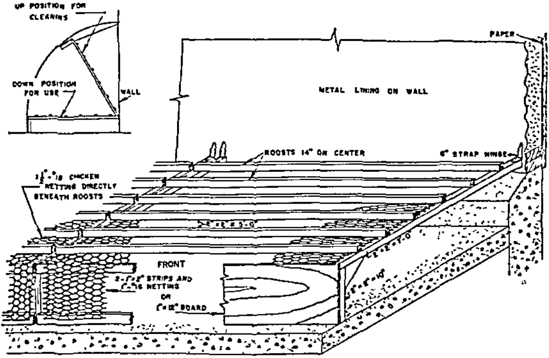


Fig. 7–16. Details for roosts and dropping pit. (Ohio Extension Bulletin 94.)

Nests. Nests should be roomy, movable, easily cleaned, cool and well ventilated, dark, and conveniently located.

Nests are usually constructed 14 inches square, 6 inches deep, and with about 15 inches head room. *All-metal nests are preferred to wood nests because of ease of cleaning and less chance of becoming infested by mites.* The entire battery of nests should be movable for convenience in cleaning.

One nest should be provided for every five or six hens. In case the birds are trap-nested, one nest should be available for every two or three birds. Dark nests are desirable because birds prefer seclusion when laying. They result in less scratching in the nest, less egg breakage, and less egg eating. Batteries of nests may be placed against the end walls or partitions and along the posts supporting the roof in the center of the house.

Trap nests differ from regular nests in that they are provided with trap doors by which birds shut themselves in when they enter. Trap nests are essential on poultry-breeding farms (Fig. 4–23).

The large-type community nest is becoming widely used in many sections. While the nests seem large, they actually occupy less space in the laying house because fewer nests are required to provide ample nesting space.

The two-section nest shown in Fig. 7–17 is 8 feet long, 2 feet wide, 14 inches high in front, and 30 inches high in back. The entrance for the birds is 8 inches square. The lid is made 16 inches wide and can be hinged with strap hinges. It will accommodate 80 to 100 birds.

The floor of the nest can be hinged so it will drop for easy cleaning, or the bottom can be made separate and the nest set on the floor. The nest can be fastened to the wall or supported as the one shown in Fig. 7–17.

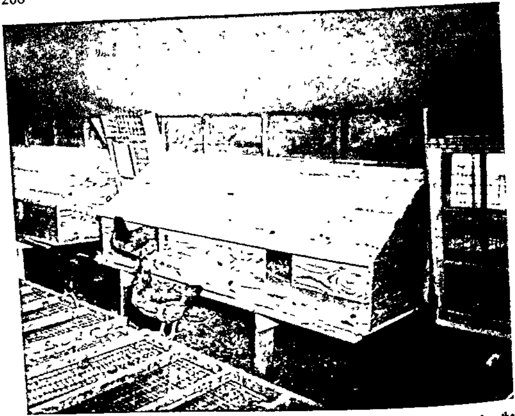


Fig. 7–17. A community nest. The front part of the lid is hinged for ease of gathering the eggs.

The perch should extend beyond the front of the nest 10 to 12 inches. For convenience of the caretaker, the nest should be placed 18 to 20 inches above the floor.

Wall feed bins. Enough feed is wasted on many farms, by rats and mice tearing open sacks, to pay for enough lumber to construct one or two feed bins in the laying house.

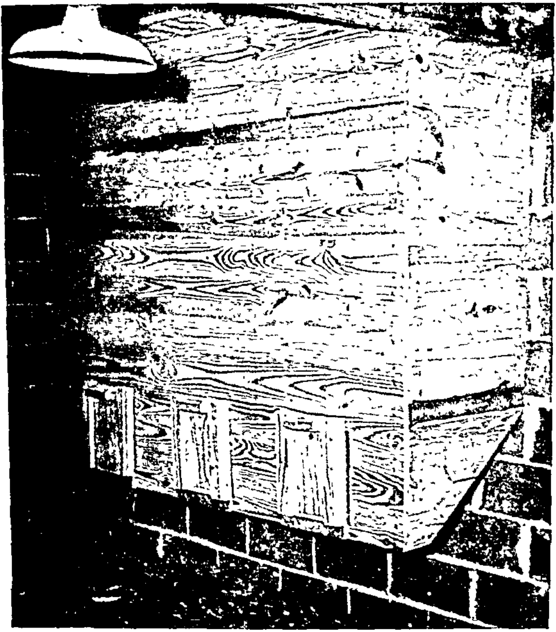
If an opening is provided on the outside wall, the bin can be filled from a truck or trailer without going into the laying house.

The bin need not be built more than 18 inches wide, and the bottom should be sloped so the front of the bin is 18 inches lower than the back side of the bin. This will allow more of the feed to run out the slide gates and also facilitate complete removal of all feed in the bin.

A wall bin that will hold 2 or 3 tons of feed can be supported on the wall and ceiling joist without floor supports. It does not take up floor space or hinder in cleaning the house (Fig. 7–18).

Feeders. The feeders should be easy to fill, easy to clean, built to avoid waste, so arranged that the fowls cannot roost on them, high enough that the birds cannot scratch litter in them, and constructed in such a manner that as long as they contain any feed at all, the fowls will be able to reach it.

Sufficient feeders should be available so that there will be one foot of eating space for every three or four birds. More hopper space is recommended



COURTESY OHIO AGRICULTURAL EXTENSION SERVICE

Fig. 7–18. A wall feed bin in the poultry house saves space, labor, and feed.

now than in former years because both the grain and mash are hopper fed, whereas in former years the scratch grain was fed in the litter. All-metal feeders that slope inward toward the bottom are more desirable than rectangular, boxlike wooden feeders.

A section of the feed hopper may be partitioned for oyster shells or other grit. It is advantageous to have the source of calcium for eggshell formation near the feed hopper.

Hanging feeders have become popular in recent years. They may serve for all ages of chickens and turkeys after they are about two weeks old (Fig. 7–19).

Automatic feeders are now in use in some large broiler and egg-laying

houses. They save labor. The feed is moved from a feed bin by a moving belt in a long trough or tube.

Watering devices. Satisfactory watering devices should keep the water clean, be available and easily cleaned, and prevent spillage of water around the vessels.

Incinerator. An incinerator should be conveniently located for burning dead or diseased birds.

Manure shed. A screened-in manure shed should be available for holding droppings or litter that cannot be disposed of at once. Manure piles are breeding places for flies. These and other insects are carriers of disease.

A hundred hens will drink from three to eight gallons of water per day, depending on size of birds, rate of production, salt content of the ration, and weather conditions.

Various forms of covers are provided for open pans and crocks to keep birds out of them. Drinking fountains are provided for young chicks, and in some cases for older birds as well (Fig. 6–2). Troughs with automatic float valves and other automatic watering devices are used on commercial farms where large numbers of birds are kept and running water is available. (Fig. 6–3.)

Lights. Artificial lights are used in laying houses to stimulate fall production of hens, to bring late- or slow-maturing pullets into production, and to delay or hasten birds through the molt.

About a forty-watt bulb to a pen that will accommodate fifty to one hundred birds is sufficient. The light is usually placed in the center of the pen and over the feeders and water stands. The use of a broad, flatlike reflector will throw more of the light toward the floor and on the birds.

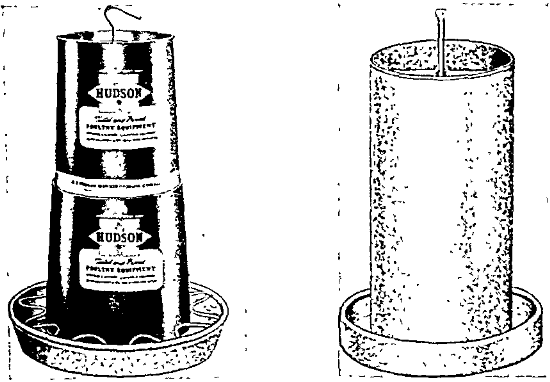
Morning, evening or all-night lights are satisfactory. Morning lights are most generally used. An automatic device is used for turning on the lights about 3:00 or 4:00 A.M.

Catching equipment. Catching coops, hurdles, and catching hooks are valuable equipment for the poultry farm. The birds may be driven into one end of the house with the aid of wire frame hurdles and on into rows of catching coops lined up end to end with the doors open at both ends. The birds may be caught with these aids with a minimum of labor and with little fright or injury to the birds. Collapsible, bottomless wire coops are of particular value to hatcherymen for culling and blood-testing work (Fig. 4–28).

Broody coop. A broody coop with a wire bottom, located at one end of the dropping pit, is useful for holding broody birds or those that have been injured. Less labor is involved in removing and caring for broody or injured birds if they can be cared for in the pens where they belong. This is especially true if the birds are on some kind of an experimental test.

Cleaning equipment. Some useful tools for cleaning purposes include shovels, brooms, scrapers, etc.

Spray pump. A spray pump is satisfactory for applying disinfectant after a house or equipment has been thoroughly cleaned. It may also be used for spraying insecticides for fly control (p. 299).



HUDSON MFG. CO., CHGO., 11, ILL. BROWER MFG. CO., QUINCY, ILL.

Fig. 7–19. Hanging feeders.

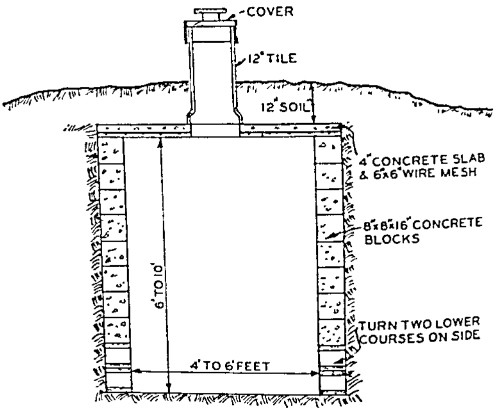
Care of the House

The house must be carefully managed if satisfactory results are to be obtained. A good house and equipment are only the first steps toward successful poultry production. Essential everyday poultry house management practices to be carried out include ventilation, temperature control, and sanitation.

Ventilation. Gravity ventilation is the natural flow of air through a house (Fig. 7–22). It depends on different temperatures of the air inside and outside of the house, between the floor and ceiling, and near a heater. Warm air is lighter and tends to rise. Cold air is heavier and tends to fall to the floor. Gravity ventilation works best in small houses with few birds involved.

In summer both the front and back windows should be kept wide open in order to secure cross ventilation. The doors in the ends of the building should also be left open, and wire or screen-covered doors used to keep the birds confined.

In the fall and spring, when weather conditions are quite changeable, the rear windows or ventilators and the end doors should be kept closed. Ventilation should be provided through the windows. Most of the troubles from faulty ventilation start in the fall. The house is often filled to capacity and left wide open with cross ventilation. If a cold, chilly storm comes along, the birds are exposed to drafts and may contract a cold developing into bronchitis or roup. Once a few of the weaker birds have become ill, the trouble is



COURTESY, WIRTHMORE FEEDS

Fig. 7–20. Disposal pit for dead birds.

easily spread to others in the flock. Correcting the ventilation after the birds have been exposed is too late to prevent the onset of the trouble. Weak, parasitized, or poorly nourished birds are most likely to be affected first.

In the winter the windows should be adjusted to take advantage of all the outside temperature possible. A thermometer should be kept outside of the house as well as inside. When the outside temperature goes above the inside temperature during the day, the windows should be opened. When the outside temperature starts to drop, the windows should be closed to retain as much heat as possible. During thawing weather, the house will become quite wet unless the windows are opened. If the temperature cannot be kept above freezing in the house, when the building is tightly constructed, the windows should never be completely closed. The more moist exhaled air kept in the house when the temperature is below freezing, the greater the danger of frozen combs and wattles.

Fan ventilation is accomplished by the use of air intake or exhaust fans. An exhaust fan arrangement used during winter that pulls air from near the floor is shown in Fig. 7–23. Intakes are placed on the opposite walls. In summer a door is opened at the top of the outlet duct, so that the warm air from near the ceiling may be pulled out and cool, outside air drawn in from the opposite side.

Another ventilating system pulls air from the attic through louvers and openings in the ceiling and forces it out through sidewall exhaust fans (Fig. 7–24). The attic air will be a little warmer in winter than air pulled directly from the outside, because heat escapes through the ceiling despite insulation and, if the roof is metal, the sun will have its effect. In summer the attic opening is closed to keep out the hot air and fan cross-ventilation is accomplished (Fig. 7–23).

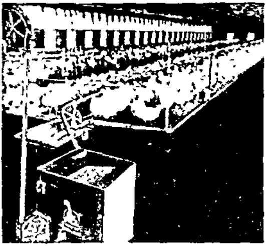

COURTESY OAKES MANUFACTURING COMPANY

Fig. 7–21. Colony laying cages with automatic feeder and belt egg conveyor.

Fans should be provided and operated with both time cycle and temperature controls. The time cycle controls can be adjusted to operate any number of minutes, usually one to ten during a ten-minute cycle. They permit removal of air even though the temperature may be low. The temperature controls shall be set to shut off all fans if the temperature drops below a given point, usually 30° F. The fans and intake and exhaust openings must be provided with automatic shutters or louvers to prevent backdrafts when the fans are not running. Fans should be purchased and operated according to the directions of the manufacturers.

Temperature control in the house. Extremes of temperature should be avoided in the house, as far as possible, through practical means. Insulation of the house and cross ventilation will help prevent extreme heat in the pens in summer.

Insulation, elimination of high ceilings or unnecessary air spaces, keeping the house filled to capacity, and proper window ventilation will help keep the inside temperature above that of the outside temperature in winter. In spite of all these practices, the temperature in the house may drop below freezing, at least a few times during the winter, in most of the central and northern states. This will interfere with egg production and in the case of breeders will result in lower fertility and hatchability.

A coal or oil brooder stove may be used in the laying house during cold winter weather. One stove will provide sufficient heat to keep the temperature from going below freezing in a well-insulated pen that will accommodate 500 to 1,000 birds. The use of a little heat will not only make the birds more comfortable but will aid in drying out the house.

Sanitation. Sanitation should be practiced every day in the year. The larger the farm and the more birds in a pen, the more rigidly it should be enforced. Every sick or injured bird should be removed as soon as noticed and put in a separate small building, used as a hospital.

Litter, if properly managed, will help keep the house warm and dry. Deep, compact litter appears to have a sanitizing effect because of its heating and

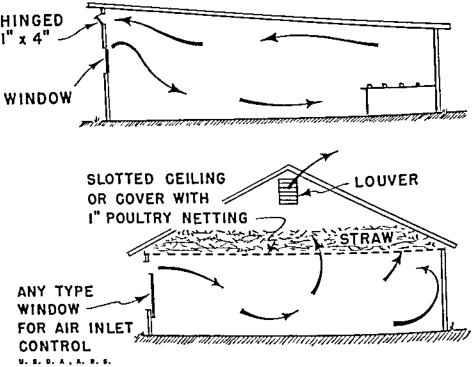


Fig. 7–22. Gravity ventilation of fully insulated houses.

production of ammonia (p. 421). Moisture is necessary for microbial action and composting (decomposition) of the litter and droppings. Litter that becomes too wet may result in excessive ammonia production and impair the health of the poultry. Frequent removal of droppings from the dropping pit will remove much moisture and help keep the litter in good condition. Frequent stirring of the litter with a fork or garden tractor will help keep the litter from caking and will keep the floor dryer. The sprinkling of acid phosphate fertilizer over the droppings and litter at a rate of ten pounds per 100 square feet of floor space, once or twice a week, will help reduce ammonia odors and retain nitrogen, thus increasing the fertilizer value of the droppings and litter.

Feeders should be kept clean.

Water vessels should be scrubbed every two or three days or as often as necessary to keep them clean and free from slime.

Nests should be kept clean and filled with a desirable nesting material.

Perches should be screened to keep the birds from coming in contact with the droppings beneath them.

The nests and perches should be treated with carbolineum for prevention of mites and for preservation of the wood.

Flies should be kept under control by use of fly sprays (p. 302).

Wild birds should be kept out of poultry houses by proper wire coverings of openings.

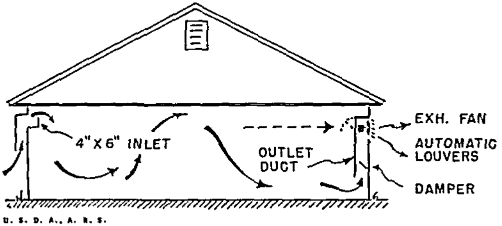


Fig. 7-23. A wall type exhaust fan and duct.

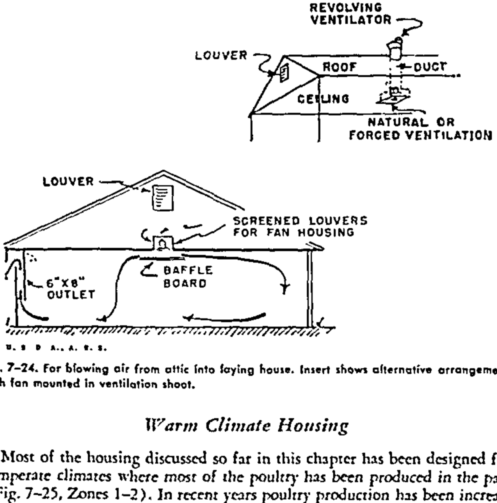
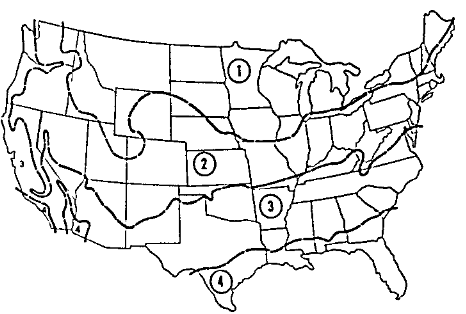


Fig. 7-24. For blowing air from attic into laying house. Insert shows alternative arrangement, with fan mounted in ventilation shoot.

Warm Climate Housing

Most of the housing discussed so far in this chapter has been designed for temperate climates where most of the poultry has been produced in the past (Fig. 7-25, Zones 1-2). In recent years poultry production has been increasing in zones 3 and 4 in the United States, in Mexico and other countries having a mild to hot climate.



U. S. D. A., A. M. S.

Fig. 7–25. Farm building zone map based on January temperatures.

Type of houses. About all that is needed for warm climate poultry housing is a shade to protect the birds from the sun and rain and a means of cooling them. Houses for birds in warm climates generally have high ceilings, ridge roof, ventilation, and open sides which may be closed on the side of prevailing storms by a canvas or panels (Fig. 7–26).

Temperature control. In warm climate poultry housing, one must guard against extremely hot weather. Some of the practices used are: (1) open houses, (2) fan ventilation, (3) roofs painted white to deflect the heat from the sun, and (4) evaporation of moisture from the birds or house.

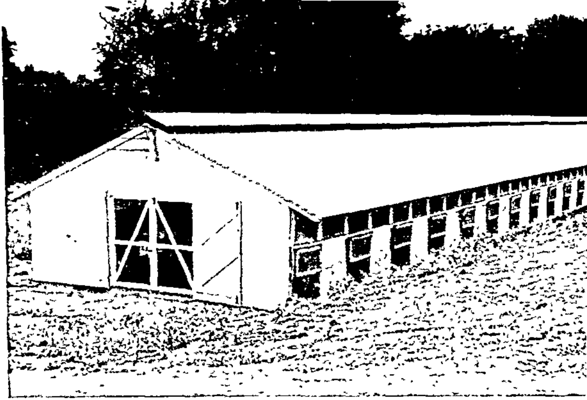
Foggers are sometimes used to produce a mist in the house or even on the bird. This produces a cooling effect by evaporation of the moisture.

Fans are sometimes used to pull air over damp surfaces and through the house. Hot, dry air is cooled by the up-take of moisture (evaporation and heat loss).

Laying Cages

Laying cages, individual (Fig. 7–27 and 28) and community (Fig. 7–21), are being used for commercial egg production. They are more suitable for use in warm climates. In areas where freezing temperatures are common, the cages have to be installed in warm houses.

Advantages of laying cages are: (1) accurate and heavy culling is possible, (2) uniform high rate of production by replacing culls with ready-to-lay pullets, (3) fewer layers show signs of broodiness when on wire floors, (4) hens cannot develop the habit of egg eating, (5) fewer badly soiled eggs are



U. S. D. A., A. R. S.

Fig. 7–26. A general purpose poultry house for warm climates. Open on both sides and with *a ridge ventilator.*

COURTESY D. F. KING, ALA. EXPT. STA

Fig. 7–27. Single-deck cages for laying hens.

Table 7–9

COMPARISON OF MODERN POULTRY HOUSING SYSTEMS[8]
SYSTEM OF MANAGEMENT

Observation	Floor with litter: Single roosts	Floor with litter: Double deck roosts	Floor with litter: Triple deck roosts	Cages: Single deck 8"	Cages: Double deck 8"	Colony 36" x 60	Slat floor	Wire floor
Floor space per layer sq ft.	2½–3	1½–2	1–1½	2½	1½	1¼–1½	1–1½	1–1½
Roosts	yes	yes	yes	no	no	no	no	no
Automatic waterers	yes	yes	yes	yes	yes	yes	yes	yes
Feeders—hand	no	no	no	yes	yes	yes	no	no
hanging	up to 700 hens	up to 700 hens	no	no	no	no	yes	yes
automatic	above 700 hens	above 700 hens	yes	can be used	can be used		Can be used to fill hanging feeders	Can be used to fill hanging feeders
Ventilation	Fan preferred	Fan	Fan	Fan preferred	Fan	Fan	Fan	Fan
Nests	yes	yes	yes	no	no	no	yes	yes
Layer replacement	Annually	Annually	Annually	Continuous	Continuous	Periodic	Annually	Annually
Hatching egg production	yes	yes	yes	no	no	yes	yes	yes
Clean out	Annual pits 2 mo.	Annual pits 1 mo.	Annual pits 7–10 da.	Annual	7–10 da.	Annual	Annual	Annual
Housing cost per layer	$5.00	$3.00	$2.00	$5 00	$3 00	$2.50	$2.00	$2.00
Floor material per hen	Litter $.10	Litter $ 08	$1.05	$1.15	$1.30	$1.40	$ .60	$ .82
Feeders, waterers, nests, etc.	$ .91	$1.07	$1.82	None	None	None	$1.04	$1.04
Total cost per bird	$6 01	$4.15	$4 87	$6.15	$4.30	$3.90	$3.64	$3.86
Labor per hen per year at $1 00 per hr.	$ .41	$ .34	$ .28	$ .46	$ .53	$ .42	$ .32	$ .32

[8] Skinner and Vaughn.

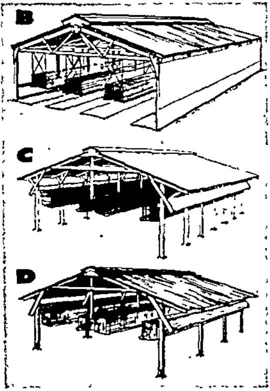


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Fig. 7–28. Cage laying houses for warm climates.

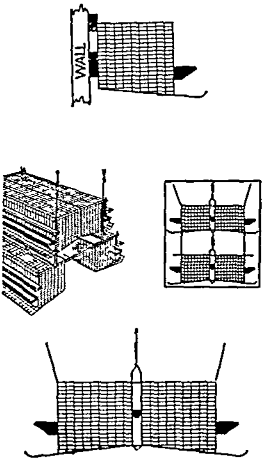

Fig. 7–29. Individual laying cage arrangement.

gathered, (6) cannibalism and pick-out habits are prevented, (7) labor is uniform throughout the year, and (8) an accurate egg record is possible.

Disadvantages of laying cages are: (1) increased housing cost per bird, especially in temperate climates (Table 7–9), (2) the control of flies (Table 9–7), (3) securing replacements, and (4) increased labor costs (Table 12–12).

Houses for laying cages in warm climates need be nothing more than a roof for shade and protection from rain (Fig. 7–28). In cooler climates the cages are installed in regular poultry houses. No supplemental heat need be provided unless the outside temperature is below 32° F.

Laying hen performance in cages is slightly better than those on a floor (Table 7–10). The birds lay a few more eggs and feed consumption is slightly less. Mortality is about the same when layers are kept in cages or on the floor.

Management of caged layers for profitable results includes: (1) replacement of layers by replacement pullets when production drops below 50 per cent, (2) keeping the cages full at all times, (3) control of flies (Table 9–7), and (4) use of the same approved feeding, watering, vaccination, egg collection, and handling practices as used for layers kept on the floor.

Table 7–10

CAGE VERSUS FLOOR PEN PERFORMANCE OF LAYERS [9]

Trial	Environment	Production Per cent	Mortality	Feed per doz. eggs (lbs.)
1 Av. of six comparisons for 10 mo. 1955–56	Floor	72	7	4.71
	Cages	76	5	4.36
2 Av. of five comparisons for 10 mo. 1956–57	Floor	68	20	4.62
	Cages	72	9	4.28

[9] Robertson.

Yards and Ranges

Range was necessary for good growth, egg production and hatchability until the discovery of vitamins and their use in poultry feeding. Today as good or nearly as good results are obtained with confinement rearing and egg production as when range is used. Less land and much less labor are required in confinement production of poultry meat and eggs than when range is provided. There is little or no difference in feed consumption or feed cost in range versus confinement production. As flocks become larger it is practically impossible to provide good, clean range, especially for the laying flock. Losses from feed eaten by wild birds and the possible spread of disease by them are eliminated by confinement production. Losses due to thieves and predatory animals may be prevented most easily in confinement production. Losses from storms may also be prevented by confinement production.

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Chapter 8

Feeding Principles and Practices

THE PRIMARY PURPOSE in keeping poultry is to transform farm feeds into meat and eggs. The fowl may be compared to a factory. Feeds, such as corn, meat scraps, grass, and oyster shells, are the raw materials. Meat and eggs are the manufactured products. The manager of the factory is the poultry feeder. The efficiency of the factory will depend upon (1) suitability for purpose, or type of bird; (2) quality of construction, or breeding of bird; (3) working conditions in factory, or health of bird; (4) raw materials, or the feeds fed; and (5) management, or feeding and care provided by the feeder.

Nutrients

The body of the fowl, eggs, and feeds are composed of various combinations of chemical compounds. They are classified according to physical, chemical, and biological properties into six general groups: water, carbohydrates, fats, proteins, minerals, and vitamins (Table 8–1). There is some similarity between the occurrence of these compounds in feeds and their occurrence in the body of the fowl or in eggs. For instance, the vitamin D content of the egg depends on the vitamin D content of the ration. Most of the feeds, however, are reduced to simpler substances in the body by processes of digestion and reassembled in different forms as body tissues and eggs.

Water. Water is the only one of the six nutrients that is a definite compound. It is composed of two atoms of hydrogen and one of oxygen (H_2O).

Water plays a highly important part in plant and animal life. It is a chemical constituent of feeds, fowls, and eggs (Table 1, Appendix). Water constitutes from 55 to 78 per cent of the live weight of chickens. Young birds, like young plants, have higher moisture content than older ones. Water softens and hydrolizes feed in the processes of digestion. As an important constituent of blood and lymph, water carries digested food to all parts of the body and waste products to the points of elimination. Water controls body temperature by absorbing the heat of cell reactions and by vaporizing moisture for excretion by way of the air sacs and lungs. It also serves as a lubricant for joints, muscles, and other body tissues.

Table 8–1

NUTRIENTS NEEDED BY POULTRY AND THEIR CHIEF FUNCTIONS AND SOURCES

Nutrients	Chief Functions for Poultry	Chief Sources for Poultr
Water	Digestion, carrier of food and waste products, and regulator of body temperature	Water, liquid milk, and young green grass
Carbohydrates	Heat, energy, and fat production	Cereal grains and grain by-products
Fats	Reserve supply of heat and energy	Cereal grains and grain by-products
Proteins	Growth and repair of body tissues, egg formation, and heat, energy, and fat production	Milk, meat scraps, fish meal, soybean meal, corn gluten meal, and cottonseed meal
Minerals	Skeleton formation, egg production, and regulation of body neutrality	Meat scraps, fish meal, milk, bone meal, oyster shells, limestone, and salt
Vitamin A	Growth; health of eye nerves, and respiratory epithelium; prevention of nutritional roup, and xerophthalmia	Green grass, dehydrated alfalfa meal, some fish oils, corn gluten meal, yellow corn, and vitamin A acetate
Thiamin (B_1)	Appetite, digestion, health of nerves, and prevention of polyneuritis	Green grass, alfalfa meal, whole grains, wheat by-products, and milk by-products
Vitamin D	Mineral assimilation; egg production; hatchability; and prevention of rickets, crooked breastbones, and thin eggshells	Sunshine, fish oils, irradiated animal sterols and yeast, and ultraviolet light
Vitamin E	Health of reproductive organs and for fertility and hatchability	Green grass, alfalfa meal, whole grains, and wheat by-products
Riboflavin (B_2 or G)	Growth, hatchability, and prevention of curled toe paralysis	Green grass, alfalfa meal, milk by-products, some fish meals, distillers' solubles, yeast, fermentation products, and riboflavin
Pantothenic Acid	Growth, hatchability, health of skin, and prevention of chick dermatitis	Green grass, alfalfa meal, milk products, distillers' solubles, and yeast
Choline	Growth, bone development, egg production, and prevention of perosis	Grains, wheat by-products, soybean meal, milk products, meat scraps, fish meal, and choline chloride
Vitamin B_{12}	Growth and hatchability	Fish meal and solubles, meat scraps, milk, and used or built-up poultry litter and fermentation products.
Niacin	Growth, feathering	Liver, yeast, milk, bran, middlings

Water generally constitutes from 5 to 12 per cent of air-dried grains and other feeds fed to poultry. It is also formed in the body as an end product of the oxidation or burning of digested food (Fig. 8–1). These two sources supply only a small fraction of the water needed by a bird for its body processes. Therefore, a liberal quantity of water should be kept before poultry at all times.

The water or moisture content of a feed or other material is determined by drying a weighed sample of the product and calculating the loss in weight.

Carbohydrates. Carbohydrates are composed of carbon, hydrogen, and oxygen, with the latter two nearly always occurring in the same proportion as in water. They occur in very small amounts in animals and poultry products. Carbohydrates constitute about 75 per cent of the dry weight of plants and grains (Table 1, Appendix). Therefore, they make up a large part of poultry rations.

The plant manufactures carbohydrates in its leaves from water brought from its roots and carbon dioxide taken from the air. Simple carbohydrates, such as glucose ($C_6H_{12}O_6$), are formed into more complex ones, such as starch ($(C_6H_{10}O_5)X$) and cellulose. Energy from sunlight is stored up in the carbohydrates. It is liberated when carbohydrates are eaten, digested, and oxidized in body tissues.

Carbohydrates serve as a source of heat and energy in the animal body. A surplus taken into the body may be transformed into fat and stored as a reserve supply of heat and energy (Fig. 8–1).

Simple sugars consist of the hexoses, or six-carbon sugars ($C_6H_{12}O_6$), and the pentoses, or five-carbon sugars ($C_5H_{10}O_5$). *Glucose, fructose,* and *galactose* are the chief hexose sugars found in plants. Glucose is of special importance in animal nutrition, for it is the chief end product of the digestion of more complex carbohydrates and the sugar found in the blood. The pentoses are constituents of more complex carbohydrates.

Compound sugars consist of two or more molecules of simple sugars. *Sucrose* ($C_{12}H_{22}O_{11}$) is one of the most common of these sugars. It consists of a molecule of glucose and one of fructose. Sucrose is found in sugar cane and sugar beets. *Lactose* is composed of a molecule of galactose, and one of glucose. It is the sugar in the milk of all mammals. *Maltose* consists of two molecules of glucose. It is formed from starch in the germination of seeds and in digestion by animals.

Starch $(C_6H_{10}O_5)_x$ consists of many molecules of glucose. It is stored in the seeds and tubers of plants as a reserve food supply. Starch is, therefore, an important source of energy in the feed of farm animals. The starch grains in different plant products differ in size and shape. An examination of starch grains under the microscope can be used to determine their source. This is often a useful method of detecting adulteration in feeds. Starch is not found in the tissues of animals. *Glycogen,* a reserve supply of carbohydrates, somewhat resembling starch, is stored in the liver and muscles of the body.

Fiber, or cellulose, is the woody component of the cell walls of plants. It is more complex than starch. Fiber is poorly digested by animals. It is

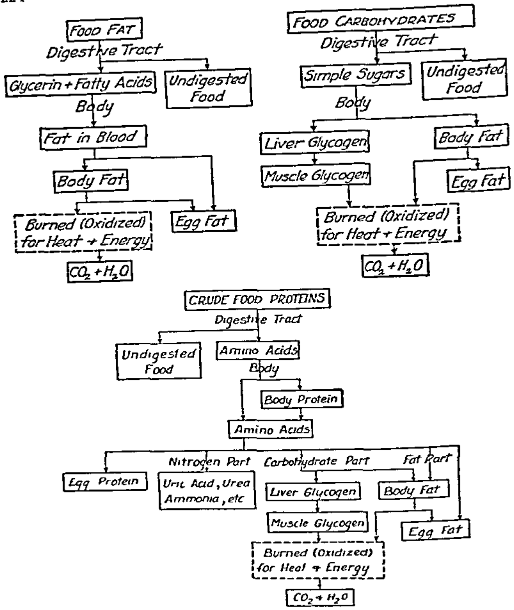

Fig. 8–1. The digestion and metabolism of nutrients by the fowl. (California Station Bulletin 417.)

determined by boiling a dry, fat-free sample in dilute acid, washing free of acid, boiling in dilute alkali, and washing. The dry solid residue remaining after all soluble material has been washed out is termed crude fiber.

Nitrogen-free extract consists of the digestible carbohydrate portion of a feed. It includes the sugars, starches, and soluble portion of the more complex carbohydrates. The total weight of the feedstuff minus the sum of the moisture, ash, crude protein, fiber, and fat is the nitrogen-free extract.

Fats. Fats are composed of the same elements as are found in carbohydrates, but in different proportions. There is much more carbon in proportion to oxygen in fats (stearin $C_{57}H_{110}O_6$) than in carbohydrates. When fats are

oxidized or burned, the large amount of energy stored up with the carbon is released. Fats have about 2.25 times the heat-production value of carbohydrates. Fats serve as a reserve supply of heat and energy. Subcutaneous fat serves as a body insulator.

Fats constitute about 17 per cent of the live weight of the fowl and 10 per cent of the whole egg. The germs of grains and seeds are also rich in fat or oil content (Table 1, Appendix). Fats are composed of an alcohol (glycerin) and fatty acids. They are formed from carbohydrates in plants. Some fats (tallow, for instance) are quite firm and hard because of their high molecular weight and saturated fatty acids. Others, like chicken fat, are oily because of their lower molecular weight and unsaturated fatty acids.

Ether extract, or crude fat, includes not only the true fats, but all related plant or animal substances soluble in ether or other fat solvents. It is determined by extracting a dry sample with ether. The loss in weight of the product after extraction is the ether extract. It includes fats, sterols, carotenes, chlorophyll, phospholipids, waxes, and essential oils.

Sterols are complex alcohols found in very small amounts in plants and animals. *Ergosterol* is a plant sterol which assumes vitamin D properties when irradiated with ultraviolet light rays (p. 230). *Cholesterol* is an animal sterol found in the skin, nerves, fat, and blood. It probably aids in transporting digested fat from one part of the body to another. When 7-dehydrocholesterol is irradiated, it assumes vitamin D properties (p. 230).

Carotene and related pigments are colored substances found in traces in plants and animals. Carotene is transformed into vitamin A in the body (p. 252). It is the yellow coloring found in yellow corn, carrots, sweet potatoes, and butter fat. Carotene is also supplied by green-colored parts of plants where its yellow color is hidden by the green chlorophyll.

Chlorophyll is the green-colored substance found in all green plants. It is necessary for the formation of carbohydrates in the leaves of plants.

Phospholipids are fats containing phosphoric acid and nitrogenous groups in their molecules. They are vital parts of living protoplasm. *Lecithin* is found in egg yolk, blood, and the liver. Other phospholipids are found in the brain and other nervous tissue.

Waxes form a coating or bloom on the surface of plants for protection against weather.

Essential oils give the plants their characteristic odors and tastes.

Proteins. Proteins are composed of carbon, hydrogen, oxygen, and nitrogen. Some of them also contain iron, phosphorus, and sulphur. Proteins are widely distributed in both plants and animals (Table 1, Appendix). They form a part of the protoplasm and nuclei of cells and are, therefore, essential to life. In plants the greater part of the proteins are concentrated in the seeds and leaves. Proteins constitute a large part of the muscles, internal organs, cartilages, skin, feathers, beak, scales, and toenails. They also occur in blood, nerve tissue, and bone. The chick contains about 15 per cent protein, the hen 25 per cent, and the whole egg 12 per cent.

Proteins are used for growth and repair of tissues. An excess protein eaten

in the ration may be deaminized and the carbohydrate portion used for heat and energy or transformed into fat (Fig. 8–1).

Nitrates and other minerals entering the plant through the roots are combined with the carbohydrates formed in the leaves to produce *nitrogenous* products, including amids, amino acids, and proteins.

Animals manufacture the proteins characteristic of their own tissues, but in general they cannot build them up from simple inorganic substances such as suffice for plants. They must depend upon the digestion products obtained from the proteins of their feed.

Proteins are large complex molecules. They are insoluble in all fat solvents. Proteins differ in their solubilities in water, salt solutions, and alcohol. These differences play a considerable part in their classification.

Amids are simple nonprotein nitrogenous products found in growing plants. They are used in making amino acids. Amids cannot be substituted for proteins in the ration, but they may be used for heat and energy purposes.

Amino acids are the building stones for proteins. The twenty-three or more known amino acids may be combined in various ways to produce many proteins, as the letters of the alphabet may be used to form innumerable words. Most of the amino acids needed in the body can be made from nitrogen digestion products in the food

Arginine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valene are essential amino acids. They must be supplied by proteins fed in the ration. Therefore, care is needed in the selection of feeds to supply the proper kind and amounts of the essential amino acids. The occurrence of some of the amino acids in feeds is shown in Table 8–2.

Enzymes are protein-like substances which aid in the digestion of foods. They occur in small amounts in plant products and are secreted in the digestive juices of animals. Amylase digests carbohydrates, lipase acts on fats, and pepsin and trypsin digest proteins.

Crude protein is the nitrogen content of a product × 6.25. This factor is used because proteins contain approximately 16 per cent nitrogen.

Minerals. Minerals, frequently referred to as ash, are essential constituents of both plants and animals. The ash content of plant products varies from less than 1 per cent in polished rice to more than 30 per cent in kelp. It constitutes 3 to 4 per cent of the live weight of the fowl and about 10 per cent of the egg.

Minerals are used for bone and egg formation, digestion, maintenance of body neutrality, respiration, and elasticity and irritability of muscles and nerves.

Calcium is needed for bone and eggshell formation, and for muscle action. *Phosphorus* is a constituent of bones, egg yolk, nerves, and other tissues. In the form of phosphates in the blood and other body tissues, it regulates body neutrality. *Iron* is needed for hemoglobin formation in the blood. In this combination, it aids in carrying oxygen from the lungs to the body tissues and cells and carbon dioxide from them to the lungs. *Sulphur* is a constituent of

Table 8–2

PERCENTAGE OF CERTAIN AMINO ACID REQUIREMENTS OF CHICKS SUPPLIED BY CERTAIN PROTEIN SOURCES IF USED TO PROVIDE 20 PER CENT PROTEIN TO THE DIET [2]

Feeds	Amino Acid				
	Arginine	Lysine	Methionine	Cystine	Tryptophan
Fish meal	123	180	127	106	128
Fish solubles, cond.	72	92	60	34	32
Meat scrap	117	138	57	74	64
Skim milk	52	130	124	69	128
Soybean meal	126	129	61	84	149
Cottonseed meal	167	82	67	114	130
Peanut meal	174	72	44	85	102
Sesame meal	178	58	136	75	174
Sunflowerseed meal	129	80	151	91	131
Linseed meal	152	68	76	108	160
Yeast	89	153	79	57	120
Alfalfa	83	100	72	126	210
Corn gluten meal	53	33	106	82	50
Corn	92	44	89	102	100
Wheat	77	62	58	97	123
Wheat bran	100	74	48	86	169
Oats	111	83	67	105	133
Barley	83	67	63	95	117
Milo	67	60	71	86	120

[2] H. J. Amquist. *Proteins and Amino Acids in Animal Nutrition*, 4th ed. 1957. U. S. Industrial Chemicals Co., New York 5, N. Y.

essential amino acids found in the egg. *Sodium* and *potassium* are constituents of phosphates in the blood, which prevent excess acidity or alkalinity. They are also constituents of the bile and other body fluids. *Chlorine* is a constituent of the hydrochloric acid, secreted in the gastric juice, for dissolving minerals and digesting proteins. *Iodine* is a constituent of the thyroid. *Magnesium* and *manganese* are constituents of bones and enzyme systems. *Copper* acts as a catalyst for hemoglobin formation. *Cobalt* is a constituent of the vitamin B_{12} (cobalamin) molecule and as such is essential for both embryo and chick growth. *Selenium*, although toxic when used in greater than trace amounts, aids in preventing muscular dystrophy in chicks who are deficient in vitamin E. It also prevents exudative diathesis. *Molybdenum* is essential for growth of chicks and maintenance of xanthine oxidase in its tissue for conversion of purines, xanthine and hypoxanthine to uric acid. *Zinc* is essential for normal bone growth, prevention of enlarged hocks and for normal feathering. Traces of bromine and other yet unidentified minerals may have functions for poultry.

The mineral or ash content of a product is determined by burning a weighed sample. The residue is the ash. The external appearance of the ash does not tell the kind, quantity, or form of the mineral elements present; however, by laborious, and expensive methods it is possible to determine the kind

and quantity of mineral elements present in an ash. The distribution of some mineral elements in poultry feeds is given in Table 1, Appendix.

Vitamins. Vitamins constitute the newest group of nutrients discovered in plants and animals. They are organic substances, occurring in feeds in very small quantities. Vitamins are essential for the health and well-being of animals. They must be stored in the egg along with other nutrients for embryo development.

Vitamins are determined by chemical or biological tests. The latter may be made by microbiological methods or by chick- or rat-feeding tests. The vitamin potency is determined by adding the product to be tested at different levels as a supplement to a bacteriological culture media or to an animal ration known to be devoid of the vitamin under consideration. The results are compared with those produced by a similar media or ration to which different levels of the known vitamin have been added.

Vitamins were discovered by observing nutritional diseases that occurred when certain foods were lacking in the ration. Since the chemical composition of the vitamins was not known at the time of their discovery, they were designated by letters. There are now more than a dozen vitamins that have been studied in detail (Table 8–1 and Table 1 in Appendix). Some vitamins are available in pure form. Other vitamins are now recognized and are being investigated.

Vitamin A. Vitamin A is a thick, pale yellow liquid at ordinary temperature. At very low temperature, it occurs in pure crystalline form. Vitamin A has the empirical formula $C_{20}H_{30}O$. It is associated with animal fats and is soluble in fat solvents. Vitamin A is formed in the animal body from carotene and cryptoxanthin eaten in the feed. True vitamin A and the carotinoid pigments from which it is formed are destroyed by prolonged heat and exposure to air.

A reserve supply of vitamin A and its precursors is stored in the liver and fat tissues of the body. Vitamin A is also stored in the egg, the amount depending upon the amount fed in the ration.

Vitamin A is necessary for growth, egg production, hatchability, resistance against respiratory and eye infections, and normal kidney function. Vitamin A deficiency diseases are nutritional roup (p. 290) and xerophthalmia.

True vitamin A is abundant in the livers of certain kinds of fish. The oils obtained from the livers of bass, eels, halibut, cod, and tuna are the richest natural sources.

Carotenes ($C_{40}H_{56}$) are plant sources of vitamin A. The carotenes are yellow, fat-soluble pigments found in green plants and yellow carrots. In fact, the green or yellow coloring is a rough indication of the richness of foods of plant origin in carotene—the more intense the coloring, the greater the carotene content Young, tender, leafy green or dehydrated grasses, such as lawn grass or clippings, and alfalfa, are good sources of vitamin A.

Cryptoxanthin, a yellow pigment found in grasses, yellow corn, and the yolk of the egg, is another source of vitamin A. Additional sources are listed in Table 1, Appendix.

The relative amounts of vitamin A and vitamin A-active carotinoids in foods can be measured by controlled feeding experiments with rats. Diets free from vitamin A, but adequate in all other respects, are fed to normal young rats until their body stores of the vitamin have been depleted. The body weights of rats that have reached this stage cease to increase and signs of an abnormal eye condition are apparent.

The food being tested for its vitamin A content is then fed as weighed daily supplements in such quantities as will promote a rate of growth equal to that induced by a standard quantity of pure beta-carotene.

The International and U.S.P. (United States Pharmacopoeia) unit of vitamin A is biologically equivalent to 0.344 micrograms of vitamin A acetate and chemically equivalent to 0.3 micrograms of vitamin A alcohol. These synthetic forms of vitamin A are more stable than the naturally occurring true forms or the precursors in the form of carotene. They are being used more extensively than fish oils and alfalfa as a source of A.

Foods tested in this way may contain both vitamin A and vitamin A-active carotinoids. The animal feeding tests do not distinguish between the growth responses due to vitamin A and these carotinoids, and for this reason the results are usually expressed as total vitamin A value.

Animal feeding tests are expensive, time-consuming, and laborious. Efforts are being made to develop chemical and physical methods of testing the vitamin A value of foods and feedstuffs. One of these is to extract the sample with a fat solvent; remove the fat, vitamin A-free pigments, and other impurities; and compare a solution of the residue with a standard solution of beta-carotene by means of a spectrophotometer or colorimeter.

Thiamin. The water-soluble, growth-promoting substance formerly known as vitamin B is now known to consist of several vitamins. The principal ones from the standpoint of poultry nutrition are thiamin, riboflavin (B_2 or G), pyrodoxine (B_6), choline, pantothenic acid, vitamin B_{12}, biotin, niacin and folic acid.

Thiamin, also known as the antineuritic vitamin, has been prepared synthetically in the laboratory. The empirical formula is $C_{12}H_{18}N_4Cl_2SO$. Thiamin is soluble in water and destroyed by heat in alkaline solution. It cannot be synthesized or readily stored in the animal body. Therefore, it must be supplied in the ration.

Thiamin is manufactured by plants and stored principally in the germs of the seeds.

Thiamin appears to play a role in the metabolism of every living cell in plants and animals. It is necessary for appetite, digestion, growth, egg production, hatchability, prevention of bacterial intestinal infection, and the prevention of nerve disorders. Polyneuritis is a specific nerve inflammation and paralysis of poultry resulting from a deficiency of thiamin in the ration.

Whole grains, wheat by-products, green grasses, alfalfa meal, milk by-products, glandular tissues, and yeast are good sources of thiamin. Since this vitamin is so widely distributed in poultry feeds, there is not much danger of a deficiency of it in poultry rations.

Vitamin C. Vitamin C is also known as ascorbic or cevitamic acid. It is needed by guinea pigs, monkeys, and human beings, and must be supplied in their rations. Poultry, swine, and cattle make their own vitamin C and do not need to have it supplied in their rations. Therefore, a discussion of vitamin C will be omitted here.

Vitamin D. The discovery of vitamin D and its use, about 1925, in the form of cod liver oil, for the control of rickets in poultry has revolutionized the poultry industry. It has made it possible to rear poultry indoors and at all seasons of the year.

Compounds of plant and animal origin may be made to possess vitamin D properties by irradiation with sunlight or ultraviolet light.

7-dehydro cholesterol is a sterol found in the skin and other tissues of animals. Upon exposure to sunlight or ultraviolet light, this sterol is activated to form vitamin D_3. This is the form of vitamin D that predominates in animal and fish oils.

Ergosterol is a sterol found in plants, especially the fungus, ergot, and yeast. Upon irradiation by means of ultraviolet light, it assumes strong vitamin D properties. Concentrated products of irradiated ergosterol are sold under the name of viosterol, calciferol, or vitamin D_2. It is satisfactory for four-footed animals but has very little activity for poultry.

Vitamin D products are closely related to fats and are associated with them. They are soluble in fat solvents. Vitamin D is fairly resistant against destruction by heat or oxidation. Vitamin D eaten in the ration may be stored in the body and in the egg.

Vitamin D is necessary for normal mineral assimilation. It prevents rickets (p. 296) and crooked breastbones in growing chickens. These bone abnormalities are characterized by poor calcification (Fig. 9–3) and low ash content. Vitamin D is also necessary for egg production, normal shell texture, and hatchability. If the hen has not stored a sufficient amount of vitamin D in the egg, the embryo will develop normally during the first week or so and then die because of inability to assemble calcium and phosphorus for skeleton formation.

The vitamin D factor may be supplied by fish oils, irradiated yeast, and irradiated ergosterol. It may be produced in animals by exposure to sunlight or ultraviolet light.

Vitamin D is determined by biological feeding tests with rats and chickens.

The International unit is the calcifying activity of .025 micrograms of irradiated 7-dehydrocholesterol (vitamin D_3) for the rat.

The U.S.P. unit is identical with the International unit; but as a standard of reference, a cod liver oil is used that has been carefully standardized against the international standard calciferol.

The I.C.U. (International Chick Unit) of vitamin D is the calcium depositing efficiency for the chick of a U.S.P. unit of cod liver oil. Vitamin D products that are to be fed to chickens should be tested on chicks rather than with rats. These two species of animals do not respond alike to all

vitamin D products. For instance, an International unit of cod liver oil is several times as potent as a unit of calciferol for the chick.

Alphatocopherol (vitamin E) is a solid alcohol. It is soluble in fat solvents and found in the nonsaponifiable fraction of the fat extract. As it occurs naturally in feeds, it is fairly resistant against heat and oxidation.

Alphatocopherol is necessary for reproduction and the prevention of muscle degeneration. Embryos die during the first day or so as a result of disintegration of the circulatory system when vitamin E is lacking in the ration and subsequently in the egg. There are also abnormal cell proliferation and hemorrhage in young embryos as a result of vitamin E deficiency. The testes in males undergo degeneration when the birds are deprived of vitamin E for several months. A deficiency of vitamin E or the presence of rancid fats, which destroys it, results in nutritional encephalomalacia (p. 295).

Vitamin E is widely distributed in poultry feeds. Poultry rations will generally contain ample quantities of it. The oil from germs of grains, especially wheat germ oil, wheat by-products, grains, green grass, and alfalfa meal are good sources of vitamin E.

The presence of vitamin E in feeds may be determined by feeding different amounts of them to rats on vitamin E-free rations and observing their ability to produce living young.

Riboflavin. Riboflavin has also been known as vitamin B_2, G, or the growth vitamin. It has been produced in pure, yellow orange, crystalline form from egg white, milk, and other plant and animal sources. In solution, riboflavin has a greenish-yellow fluorescence. Its empirical formula is $C_{17}H_{20}N_4O_6$. Riboflavin is stable at temperatures at which B_1 is destroyed. It is water soluble, gradually destroyed by light, and easily destroyed at high temperatures in the presence of alkali.

Riboflavin is stored in the white of the egg for the development of the chick embryo. It gives the albumen its slight greenish-yellow opalescence.

Riboflavin is essential for cellular oxidations. It is necessary for growth and hatchability. A deficiency of riboflavin in the egg results in early embryo mortality. It is also necessary for preservation of health of peripheral nerves and the prevention of the acute neuromalacia and the less acute "curled toe paralysis."

Sources of riboflavin for poultry are milk whey, yeast, liver meal, alfalfa meal, and green grass. Additional sources are given in Table 1, Appendix.

Riboflavin content of feeds is determined biologically with rats and chickens, and chemically by measuring the fluorescence in concentrated extracts. It may also be determined by microbiological methods.

Vitamin B_{12} (APF factor) (cyanocalbamin). This is one of the B-complex vitamins which was first found in animal tissue and excreta. Hence, the name animal protein factor (APF). It is now known that vitamin B_{12} and other as yet unidentified factors may be synthesized by a number of microorganisms. Vitamin B_{12} is necessary for growth, normal feathering, and hatchability. Good sources are fish products, packing house by-products,

animal feces, used poultry house litter, yeast, and microbiological fermentation products. Methionine, choline and pantothentic acid have vitamin B_{12} sparing effects.

Vitamin K. Vitamin K is also known as the antihemorrhagic vitamin. It is a fat-soluble product which was first extracted from alfalfa. It has now been prepared synthetically. Vitamin K is a naphtho-quinone. Menadione sodium bisulfite is a commercial source. It is destroyed by oxidation, sunlight, and strong alkalis or acids.

Vitamin K is necessary for the normal clotting of blood. A deficiency of the vitamin results in internal, subcutaneous and intramuscular hemorrhages and delayed clotting time of the blood. It also results in bleeding from the pinfeathers, internal hemorrhage, and greater loss of blood resulting from cannibalism.

Vitamin K is found in green grass, alfalfa meal, fish meal, and meat scraps.

Choline. This vitamin is a constituent of complex fats. It is used for growth, normal bone development, fat metabolism, egg production and the prevention of perosis (p. 298). Liver meal, fish meal, yeast, wheat germ, soybean meal, tankage, meat scraps and distillers solubles supply choline.

Pantothentic acid. This vitamin is necessary for growth, feathering, hatchability and prevention of chick dermatitis.

Nicotinic acid. This vitamin is necessary for growth, feathering, and a normal intestinal tract (p. 222).

Biotin and Pyrodopine (B_6). For normal metabolism and growth.

Inositol. This water-soluble vitamin is found in nearly all plant and animal tissue, including the egg and chick. The chick may be able to synthesize this vitamin from the ration.

Folacin (folic or pteroylglutamic acid) is necessary for growth, the normal development of feathers, and prevention of a type of anemia in chicks. It is necessary for the synthesis of nucleic acid derivatives. Feeds normally fed in poultry reactions supply an adequate amount of folacin.

Other vitamins (unidentified factors). Some nutrients, as yet unidentified, are essential for growth and hatchability. The *"fish factor"* is one of them. It occurs in fish solubles, fish meal, liver meal, and certain fermentation products. The *whey factor* is found in whey products, yeast, distillers, and fermentation solubles. The *grass juice factor* occurs in green grass, alfalfa, and fermentation products. The *egg factor* is essential for growth. It occurs in the yolk. The above factors may owe their nutritional value, in part at least, to their trace mineral content.

Enzymes. Enzymes occurring in grains or supplied in dry form from certain fungi sources may be used to increase the feed efficiency of grains, especially certain strains of barley.

Chemical Feed Additives

There are a number of substances, which when added to rations in minute amounts and under certain conditions of stress, promote growth or egg pro-

duction and improve feed efficiency. They do not act as nutrients but control microorganisms and influence metabolism in such a manner that the nutrients may function more efficiently. Since chemical additives are used in very small amounts, they need to be thoroughly premixed before being mixed in rations.

Premixing should be used when ingredients, vitamins, amino acids, drugs, hormones, or other substances are added to rations at less than one per cent level. Many of these substances are already premixed when purchased. However, they are usually added to rations in such small amounts that further premixing is desirable.

Microgram amounts of nutrients are first thoroughly mixed in 0.5 to 1.0 pound of a suitable carrier, usually corn meal or soybean meal. The primary mixture is then added to about 10 to 20 additional pounds of the carrier and again thoroughly mixed before being added to the large batch of feed being mixed.

Several of the small quantity ingredients may be incorporated in a single premix. Care must be taken so that ingredients incorporated in a premix do not react with each other and result in destruction of their potency. A premix of trace minerals is generally made and a separate one for vitamins and amino acids.

Antibiotics are specific chemical agents produced by microorganisms such as yeasts, molds, and bacteria. They are used to combat infection either by preventive or curative procedures. Antibiotics fed at a level of 2 to 10 grams per ton of feed stimulate early growth of poultry not maintained in a germ-free environment. Since they stimulate growth rate and improve egg production under conditions of stress, they aid efficient feeding. Antibiotic feeding recommendations are indicated in Tables 8–7 and 8–11.

A large number of antibiotics have been discovered, studied, and used in poultry feeds since 1950. Those most widely used in poultry rations are aureomycin, terramycin, penicillin, bacitracin, and streptomycin. They require thorough premixing before use in feed. Antibiotics should be used according to the directions of the manufacturers.

Arsenicals. Arsonic acid (3-nitro, 4-hydroxyphenylarsonic acid) and arsanilic acid (para-amino phenylarsonic acid) are used in a similar manner as antibiotics to promote growth and increase egg production under stress. Arsonic acid is usually used at 45 grams per ton and arsanilic acid at 90 grams per ton. The arsenicals require thorough premixing before use in feed. Arsenicals should be used according to the directions of the manufacturer.

Nitrofurans. Furazolidone (NF-180) and nitrofurazone are sometimes fed in poultry rations at low levels (15 to 50 grams per ton) to protect against disease under conditions of stress. They act like antibiotics and arsenicals by being effective against many microorganisms and at times improve growth rate, egg production, and feed efficiency.

Hormones. Diethylstilbesterol pellets implanted underneath the skin (p. 177) or the use of 30 mg. dienestrol diacetate per pound of feed about a month before young poultry is marketed, improves the finish by increasing

the fat content. Hormones are not very effective in increasing weight gains and feed efficiency.

Tranquilizers. Tranquilizers are drugs which allay anxiety and tension without necessarily deadening pain or inducing sleep. Reserpine fed at low level (1 to 25 grams per ton) may reduce fighting, cannibalism, feather eating, and other faults. The beneficial effects of this drug, tetrahydrozoline, and others may prove of value in promoting weight gains and feed efficiency.

Antioxidants. Butylated hydroxytoluene (BHT) or butylated hydroxyanisole (BHA) added to fats, alfalfa, and mixed feeds at low levels (0.01 to 0.025 per cent) retards the development of fat rancidity and the destruction of fat soluble vitamins. The antioxidant should be thoroughly incorporated in a fine, textured premix before incorporation in a feed or ration (p. 233).

Metabolism

Metabolism is here used to designate all of the processes undergone by a food from the time it enters until it leaves the body.

Digestion

Digestion is the disintegration of feeds into simple nutrients in the intestinal tract for absorption and use by the body tissues. It involves a series of mechanical and chemical processes and is influenced by many factors.

Feed intake and storage. The feed is picked up with the beak and swallowed. It is stored in the crop (Fig. 3–4) until it can be ground and mixed with digestive juice from the glandular stomach, and ground in the gizzard.

It is a common belief that hard insoluble grit is necessary, or at least desirable, in the gizzard for the grinding process. Experimental data are conflicting on this point. In fact, the presence of hard insoluble grit and foreign material in the gizzard may take up valuable space and interfere with the grinding process and the passage of the ground feed.

Digestion of carbohydrates. As the ground feed passes from the gizzard into the duodenal loop, pancreatic juice is secreted from the pancreas into this region of the intestinal tract. At the same time, alkaline bile salts, produced in the liver and stored in the gall bladder, are also secreted into the duodenal loop. The bile salts neutralize the acidity of the intestinal contents in this region of the intestine and produce an alkalinity. Three digestive enzymes are secreted in the pancreatic juice. One of these is amylase, which breaks starch down into disaccharides or complex sugars. As the food passes along into the small intestine, sucrase and other sugar-splitting enzymes, secreted in this region, further hydrolize or digest the compound sugars into simple sugars, chiefly glucose. Simple sugars are the end products of the digestion of carbohydrates.

Starches and sugars are easily digested by poultry, while the pentosans and crude fiber are poorly digested (Table 4, Appendix). The intestinal

tract in the chicken is so short and the passage of food through it is so rapid, that bacteria have little time to work on the complex carbohydrates.

Digestion of fats. The bile salts from the liver emulsify the fats in the duodenal loop. They are then acted upon by an enzyme, lipase, a product of the pancreatic juice. The fats are digested or broken down into fatty acids and glycerol. These are the end products of fat digestion.

Digestion of proteins. While the feed is being ground and mixed in the gizzard, the pepsin-hydrochloric acid mixture breaks some of the proteins down into less complex fractions as proteoses and peptones.

While fats and carbohydrates are being digested in the duodenal loop, trypsin from the pancreatic juice breaks down some of the proteoses and peptones into still simpler products—amino acids. Erepsin, secreted in the small intestine, completes the digestion of protein split products into amino acids. These are the end products of protein digestion.

Digestion of minerals and vitamins. Minerals are dissolved rather than digested. Many of them change from the solid to the liquid form in the gizzard. Oyster shell and limestone grit, for example, are dissolved in this region.

The digestion and metabolism of vitamins in the body are not well understood. Carotene, the precursor of vitamin A, is transformed into true vitamin A in the liver. The bird manufactures vitamin C from digested feed fragments, in the body. Cholesterol in the skin is transformed into vitamin D by exposure to sunlight or ultraviolet light.

Rate of digestion. Digestion is rapid in the chicken. The time required for food to pass from the mouth to the cloaca is about two and one-half hours in a laying hen. The rate of passage is much slower (eight to twelve hours) in birds out of production.

Absorption and Assimilation

Absorption of nutrients. The digested nutrients pass through the intestinal wall into the blood stream. Most of the absorption takes place from the small intestine. The surface for absorption is greatly increased by the presence of innumerable villi or finger-like projections.

Digested nutrients in the form of simple sugars, amino acids, and dissolved minerals pass through the wall surface into the blood capillaries. The method or methods by which the materials pass through the intestinal wall are not well understood.

Digested fats pass through the intestinal wall into the lacteals of the lymphatic system. Here again, they form neutral fats. The fats in the lymph are more like body fat than like that of the feed eaten. The fats pass along with the lymph and enter the venous blood stream near the heart.

Transfer of nutrients. The digested nutrients, entering the blood stream by way of the capillaries in the intestinal wall, are collected in the portal vein. It transports blood and the absorbed food nutrients to the liver, on their way to the heart.

As the digested nutrients pass through the capillaries of the liver, most of the glucose is transformed into glycogen (Fig. 8–1) for storage in the liver and muscles. Some amino acids and nitrogenous products of tissue metabolism are deaminized as they pass through the liver. The carbohydrate fractions are made available for heat and energy purposes and the nitrogenous fractions are transported to the kidneys for elimination. The liver also removes some of the fat from the blood stream for storage. This accounts for the pale yellow livers in fat birds and newly hatched chicks. Many impurities absorbed from the intestinal tract into the blood stream are retained by the liver cells as the blood passes through its capillaries. In case of absorbed poisons, a high concentration of them is usually found in the liver.

The blood, carrying the digested nutrients, passes from the liver by way of the hepatic and postcaval veins to the heart. It passes from the heart to the lungs, where carbon dioxide and water are given off and oxygen is taken in. The blood is returned from the lungs to the heart, and is then pumped out through the arteries to all of the tissues of the body.

The digested nutrients pass from the capillaries to the lymph which bathes the tissue cells. The lymph serves as a medium of exchange between the capillaries and the tissue cells. It carries digested food to the cells and waste products from them.

The assimilation of nutrients. *Glucose* is burned in the cells for heat and energy production, the end products being heat or energy, carbon dioxide, and water. The process may be represented by means of a chemical equation, thus:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2} = \underset{\substack{\text{Heat}\\\text{or}\\\text{energy}}}{\Delta} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{6CO_2} + \underset{\text{Water}}{6H_2O}$$

An excess of digested carbohydrates, over and above that stored as glycogen, is transformed into body and egg fat.

Fats are gradually removed from the blood stream and stored as adipose tissue mainly, under the skin in the abdominal region, along the intestines, and in the egg. They serve as a reserve supply of heat and energy. In case of inadequate food supply, as soon as the glycogen is used up, the fats are burned with the same end products as formed by the burning of carbohydrates. As long as fats are present, the proteins are protected from consumption.

Amino acids, absorbed into the blood stream, are used to build new body tissues, rebuild worn-out tissue, and to form the white and much of the yolk of eggs Excess amino acids may be used for heat and energy purposes or transformed into fats.

The carbohydrates and fats are preferable to proteins for the production of heat and energy because they are cheaper. Their digestion and metabolism, including the excretion of the resulting waste products, require less work on the part of the body than is required by protein food.

Minerals absorbed into the blood stream are transformed into bone, put into the shell and yolk of the egg, and used in the blood. There is also some storage of excess minerals taken into the body.

Vitamins are stored in the liver and in the egg, and to a lesser extent in other tissues of the body. There appears to be greater storage of the fat-soluble than of the water-soluble vitamins.

Energy Production

Energy is required for all of the body processes, such as digestion, assimilation of food, elimination of waste products, the heart beat, respiration, body movements, and maintenance of body temperature. It is supplied by the feed eaten.

Gross energy. The gross energy value of any feed for the animal depends on the amount of energy that it will furnish when burned. It is determined by burning a weighed sample in pure oxygen gas under pressure in an apparatus known as a calorimeter. The heat given off is taken up by water surrounding the combustion chamber and is measured with an exceedingly accurate thermometer.

The unit of measurement employed in measuring heat and energy is the calorie (c). It is the amount of heat required to raise a gram of water 1° C. A large calorie (C) is equivalent to 1000 small calories (c). A therm (T) *is 1000 large calories.*

The gross energy of one hundred pounds of various substances when burned is as follows:

	Therms
Corn meal	180.3
Linseed meal	210.3
Pure digestible protein	263.1
Pure digestible carbohydrates	186.0
Pure digestible fat	422.0

Digestible protein yields considerably more heat than a similar weight of carbohydrates. Fat yields more than twice as much energy as a similar weight of carbohydrates.

Available energy. The available energy of a feed is the gross energy minus the energy lost in the feces, urine, and combustible gases. It is determined by placing the animal in an apparatus known as a respiration calorimeter (Fig. 8–2), and keeping records of the feed eaten and of the feces, urine, and combustible gases given off. The gross energy of samples of the products are determined and from them the available energy is calculated.

Net energy. The net energy of a feed is the available energy minus the energy lost in the work of digestion. The work of digestion includes the energy required for grinding in the gizzard, intestinal contractions for moving the food, secretion of digestive juices, and increased work of the heart and lungs resulting from these processes.

All of the energy consumed in the processes takes the form of heat, and helps to warm the body. It cannot be used for other body purposes, because the body has no means of converting heat into other forms of energy.

In addition to the losses of energy due to the actual work of grinding, mixing, digestion, and assimilation of food, a further loss occurs through the speeding up of general metabolism in the body, which always follows the consumption of food. It has been found that the rate of metabolism is at once increased when nutrients are absorbed from the digestive tract following a meal. As a result, more heat is produced. This additional production of heat is sometimes called the "specific dynamic effect" of the food nutrients.

The net energy of a feed is used first of all to meet daily maintenance needs. These include the work of the heart, lungs, and other organs, as well as work done by the muscles in producing body movements. Any surplus of net energy may be used for growth, fattening, or egg production.

Metabolizable energy of a feed is the gross energy of the feed less the amount lost in the feces and urine. It may be calculated according to the following formula (Hill and Anderson, 1958).

Metabolizable energy (per gram of feed) equals the energy in diet-energy in the excreta minus 8.22 N. It is assumed that protein tissue, if oxidized for energy purposes, would yield uric acid as the sole excretory product, and the value 8.22 is the energy of uric acid per gram of nitrogen. Metabolizable energy gives a better measure of the energy value of a feed than the productive energy, because it is not influenced materially by level of feed intake, rate of growth, or nutrient balance in the diet.

Productive energy (*net energy*) is that part of the total energy consumed minus the portion estimated as necessary for body processes (digestion, respiration, heart beat, heat production, etc.). It is the portion available for tissue growth or fat deposit. It is determined by carcass analysis and use of the following formula:

$$WM + G = FX$$

Where W is chick weight; M is the maintenance requirement per unit weight; G is the energy gain computed from carcass composition; F is the food intake; and X equals productive energy value of the diet per unit weight (Hill and Anderson, 1958). The estimation of maintenance requirements is subject to considerable error. One of these is the difficulty in determining digestibility of feed with chickens (p. 234). Productive energy calculations are less valuable than metabolizable energy determinations for measuring the true energy value of a feed.

Basal heat production. The heat produced by an inactive fasting animal is known as the basal heat production. By measuring the oxygen consumption and the carbon dioxide elimination, it is possible to estimate the basal heat production and to determine the kind of tissue being oxidized.

The volume of carbon dioxide produced divided by the volume of oxygen consumed is known as the respiratory quotient (R.Q.). The respiratory quotient of carbohydrates is 1, fats .7, and proteins between .7 and 1.

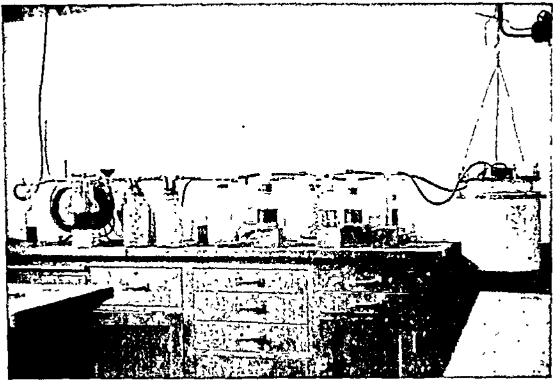

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Fig. 8–2. An apparatus used to measure the oxygen consumption and carbon dioxide and heat production of a bird. The bird is confined in the chamber at the right. The air is drawn through chemical agents before and after it leaves the chamber in order to absorb various constituents. The volume of air is measured by the air meter at the left.

The determination of the respiratory quotient and basal heat production are useful in studying nutritive requirements and in the diagnosis of disease.

The critical temperature. The critical temperature is the environmental temperature below which the heat produced by the normal body processes is no longer sufficient to maintain the normal body temperature. When the environmental temperature drops below the critical temperature of the bird, it must use food primarily for the production of body heat. In the absence of food, it must oxidize body tissues for this purpose. Experiments conducted at the Illinois Agricultural Experiment Station have shown that the critical temperature of the inactive fasting hen is 62° F. If the hen is in production, has access to feed at all times, and is free to move about, the critical temperature is lowered to 15° F.

Excretion

Excretory products include materials which have not been digested and waste products resulting from body metabolism.

The feces. The feces includes indigestible food, intestinal bacteria, digestive juices, bile, worn-out intestinal lining tissue, and mineral material resulting from body metabolism.

Some of the unabsorbed and undigested contents of the small intestine back up into the ceca. A little absorption may take place here. The ceca con-

tract and force the material out into the large intestine about once a day. As the undigested food passes along through the large intestine, some of the water is reabsorbed into the body circulation. The undigested material is voided from the large intestine into the cloaca and from it to the outside of the body as feces.

The mixture of feces and urine voided by birds is known as manure. It contains about 1.44 per cent nitrogen, .99 per cent phosphoric acid, and .39 per cent potash. A hen will produce about forty-three pounds of manure a year. It is of considerable importance as a fertilizer.

The urine. The urine consists mainly of nitrogenous waste products and water resulting from body metabolism processes.

Liquid waste products pass out of the blood stream into the kidney tubules as the blood passes through the capillaries of the kidneys. The material passes from the kidney through the ureters to the cloaca, where it is excreted into the cloaca as urine. As the liquid urine passes along through the ureters, in the region of the large intestine, much of the water in it is reabsorbed into the body circulation. The urine is generally a white pasty material which is mixed with, and coats, the droppings.

About 65 per cent of the urinary nitrogen excreted by birds exists in the form of uric acid. Other constituents include purine nitrogen, 9.6 per cent; urea, 6.5; ammonia, 7.5; creatine, 4.5; and allantoin, 3.8.

A hen probably secretes 700 to 800 cc. of liquid urine from the kidneys every twenty-four hours. Much of the water is reabsorbed so that very little liquid urine is eliminated from the body.

Carbon dioxide and water elimination by respiration. A five-pound hen will exhale about fifty-two liters of carbon dioxide every twenty-four hours. This will vary greatly, depending upon the activity and egg production of the bird.

The water elimination of a hen per day is about .37 pounds by way of the excreta and .09 by way of the lungs. This also will vary within wide limits, depending upon the temperature, activity of the bird, kind of ration fed, and the rate of production.

Determination of the Value of Feeds

There are several methods used for judging the value of feeds. These include chemical and microscopic analysis, digestibility, energy value, and biological value for growth and reproduction.

Chemical analysis of feeds. Chemical analysis of feeds and rations tells the amount of the different groups of nutrients present. Such analysis aids in judging their food value; however, it is by no means the final answer. The usual chemical analysis of feeds includes moisture, crude protein, ether extract (fat), crude fiber, and ash.

The *crude protein* analysis gives the amount of nitrogen present in a feed and indirectly the crude protein (p. 225). It does not show the source of the protein or the kinds and amounts of essential amino acids present. Just as

a chain is no stronger than its weakest link, a protein feed is no better than the smallest amount of an essential amino acid which it contains. Therefore, crude protein content of a feed does not give much information regarding its protein value. The feeding value of protein feeds is now determined by nitrogen retention or growth studies (p. 242).

The *ether extract* or crude fat analysis includes all of the substances soluble in fat solvents (p. 225). Most state laws require a statement of the minimum fat content. Some of the fatlike substances are unpalatable and poorly digested, while others become rancid and cause destruction of vitamins present in feed mixtures.

The *crude fiber* analysis is of value (p. 223). Crude fiber is poorly digested. Very little fiber is utilized by poultry. The contents of coarse, stemmy materials, hulls, and other woody materials are determined by crude fiber analysis.

Ash or mineral analysis is of some value (p. 227). It gives the amount but not the kind of mineral elements present or the forms in which they exist. Mineral elements may be determined by chemical analysis. The procedures are often expensive and time-consuming. Spectrographic analysis, which is now being used on an extensive scale, greatly shortens the time required to determine the kinds and amounts of mineral elements present in ash.

Chemical analysis is not a very satisfactory means of determining some of the vitamins present in a feed.

Microscopic analysis of feeds. Microscopic analysis is of value in determining the presence of ingredients in mixtures. It may be used for checking claims made for the presence of ingredients in mixtures. It may also be used to detect adulterants and foreign substances in feeds and mixtures.

Within certain limits, microscopic analysis may be used to estimate the quantities of ingredients in mixtures. It is of little value in determining the quality of ingredients or mixtures. Two substances may have the same chemical analysis and look alike under the microscope, yet vary greatly in feeding value.

Microscopic analysis is an aid and supplement to chemical analysis in determining the value of a feed. Other determinations need to be made. Chemical and microscopic analyses do not give the amino acid, mineral element, and vitamin content; the palatability; digestibility; or value of the feed for maintenance, growth, egg production, fattening, or reproduction (hatchability).

Biological analysis of feeds. Biological analysis of feeds involves feeding tests with animals. They may be made in the laboratory with small animals such as chicks or rats, or with larger animals and poultry flocks under practical farm conditions. Biological analyses include studies of palatability, digestion, balance experiments, energy metabolism, and effects of feeds on growth and reproduction.

Palatability of feeds. Palatability is the first factor determining the biological value of a feed. If a feed is not consumed readily, it cannot be expected to produce good growth or production. Unpalatable feeds do not stimulate normal intestinal movements and secretion of digestive juices. They have a tendency to remain in the crop longer than palatable ones.

A bird probably chooses food by sight and touch more than by smell and taste. Whole grains are more palatable than finely ground ones. Wheat is more palatable than the other cereal grains. Coarsely ground mash is preferred to finely ground material. Freshly ground grains are more palatable than stale ground grains. Moist mash is more palatable than dry mash. Animal protein feeds, such as milk, meat scraps, and fish meal are eaten more readily than vegetable protein feeds, such as soybean, cottonseed, and linseed meals.

Digestibility of feeds. Feeds must be digested before they can enter the blood stream and be transported to the tissues. Furthermore, the tissue cells can utilize nutrients only in the form of the simple end products of digestion (Fig. 8–1).

The urine and feces are excreted together. The crude protein in the urine has been digested. It results from the breakdown of protein material in body processes. Troubles are encountered in separating the urine and feces in digestion trials with poultry.

The *coefficient of digestibility* is the percentage of a feed or nutrient consumed that is digested. For example, if 100 grams of corn are consumed and 10 grams are excreted by way of the feces, the amount digested is $100 - 10$, or 90 grams. This amounts to $90 \div 100$, or .9 digested; or in terms of percentage, $.9 \times 100 = 90$, or 90 per cent is the coefficient of digestibility.

The digestibility of each nutrient is figured separately. They are then totaled in order to get the total digestibility of the feed. To calculate the digestibility of a mash feed, determine the number of pounds of digestible nutrients in the quantity of each feed used and then total the feeds and their digestible nutrients.

The digestibility of nutrients in some poultry feeds tested with chickens is given in Table 4, Appendix.

Factors influencing digestibility of feeds are important. Young and healthy animals digest feed better than old or sick animals. A given quantity of feed fed in small amounts at a time is digested more efficiently than when fed at one time. Animal feeds are generally digested better than plant feeds because they do not contain fiber, which must be disintegrated so that the digestive juices can attack the nutrients. High temperature used in the processing and drying of certain feeds generally reduces their digestibility. Combinations of feeds fed in a mixture influence the digestibility of each of the ingredients. It is believed that certain feeds—milk, for instance—create a more favorable environment for useful intestinal bacteria. These, in turn, bring about more complete digestion of the feed.

Retention value of feeds. The value of feeds is sometimes measured by balance experiments. Records are kept of the intake and outgo of certain elements during a definite period of time. For instance, the biological value of proteins for growth of chickens has been measured by nitrogen balance experiments (Fig. 8–3). The test periods are generally of short duration. They do not measure the value of the feed for extended periods of growth or for reproduction and health.

Energy value of feeds. There are other losses that must be taken into consideration, in addition to feed that is not digested. These include the energy

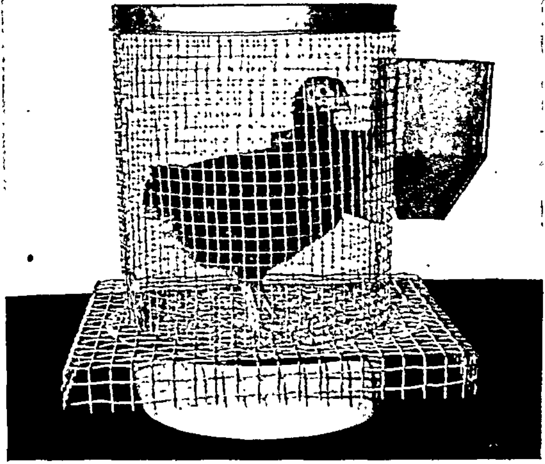

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Fig. 8–3. Cage used in nitrogen-balance experiments with feeder specially designed to prevent wastage.

lost in grinding and mixing, digestion, and absorption. Various types of respiration apparatus and respiration calorimeters have been designed to measure these losses (*Fig. 8–2*). The more complete type of respiration apparatus is an air-tight chamber in which the animal is placed. This is so equipped that all of the air entering the chamber and leaving it can be accurately measured and analyzed. All food, feces, and urine are likewise carefully weighed and analyzed.

The amount of carbon and nitrogen stored or lost can be measured. From this information, the amounts of body protein and fat that have been stored or lost can be computed, and likewise the gain or loss in energy.

Limitations of net energy values are worthy of note. The net energy value of a feed does not measure its value for maintenance. For instance, roughages have low net energy values. They are much better for the production of body heat than for the production of fat.

Net energy values are far more expensive to determine than total digestible nutrients. The latter give a fair idea of the value of a feed for heat production.

The net energy values differ with different species of animals. For instance, studies at the University of Illinois have shown that the net energy value of

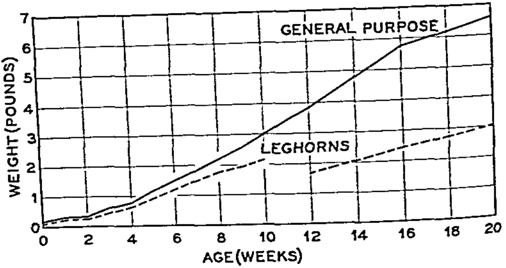


Fig. 8–4. Age of chick influences rate of growth.

corn grain for chickens is 128.5 therms per 100 pounds. This is 52 per cent higher than the net energy value of the same grain for fattening cattle.

The net energy values of feeds are higher when scantily fed than when fed liberally.

A deficiency of vitamins and certain amino acids in a ration reduces its net energy value.

Growth value of feeds. The value of a feed as determined by growth studies shows what a feed will do. This is often measured in the laboratory by feeding tests with rats and chicks. Tests made with rats give an indication of results that may be expected when the feed is fed to other animals. Final tests need to be made with the animals for which the feed is intended. Different species of animals do not always respond the same when fed the same ration. For instance, the chick and the rat do not need vitamin C, while man does need it.

The *number of chicks required* per lot to show growth differences in two feeds will depend on the differences to be shown. Where there is quite a noticeable difference in feeds, twenty or twenty-five chicks are sufficient. Where there is very little difference many more chicks are required.

The *length of the feeding trial* for growth studies of chicks is usually eight weeks. Almost all nutritional troubles will show up in this length of time. Tests have shown that differences in lots of chicks at four weeks of age will usually remain so at eight and sixteen weeks. Birds are more sensitive to growth factors in feeds early in life than later on.

The *age of the chick* influences the rate of growth. There is an early period of increasing rate of growth (the first eight to sixteen weeks) and a later period of decreasing rate (Fig. 8–4). If early growth rate is inhibited by low protein levels or other causes, the later growth rate will be greater than normal.

The *amount of feed consumed* is another important factor governing the rate of growth. The older the bird during the growing period, the greater

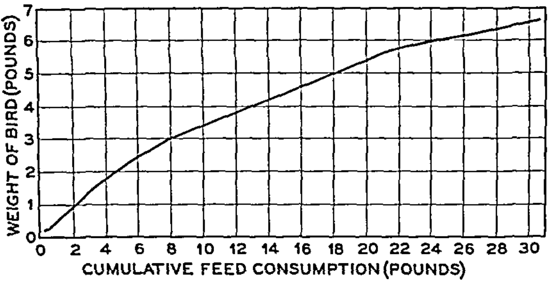


Fig. 8–5. Amount of feed governs growth.

the proportion of feed eaten that is used for maintenance and the smaller the proportion used for growth (Fig. 8–5). Each succeeding 1000 grams of feed eaten by young chickens results in about 9 per cent decrease in the amount of gain secured. The rate of growth is more a function of food intake than time when birds are fed good rations. One may predict the live weight better than the age of chicks any time during the first six weeks by knowing the amount of feed consumed.

The *protein level* of the ration influences the rate of growth of chicks. Birds fed a high protein ration make faster earlier growth than those fed a low protein ration (Fig. 8–6). Those fed a low protein ration make faster growth later in life.

The *vitamin content* of the ration, especially riboflavin and B_{12}, influences the rate of growth.

Reproduction value of feeds. The final test of the value of a feed is its efficiency for growth and reproduction through succeeding generations. If growth, health, and reproduction are normal through one generation, they will generally remain so during succeeding generations.

In the case of poultry, it takes a better feed to produce hatchable eggs than merely to produce eggs. This is to be expected since the hen must store all the nutrients for the development of the embryo in the egg. If an inadequate supply is stored, the embryo will develop for a time and then die.

Some feeds are satisfactory for maintenance but not for growth or egg production. Others are satisfactory for growth and egg production but not for hatchability. However, a feed that produces good hatchability is satisfactory for maintenance, growth, and egg production.

Poultry Feeds

The feed cost amounts to about 60 per cent of the total cost of poultry production. The results obtained are largely dependent upon the rations and how

they are fed. The value of a ration is determined by the kind, quality, and amounts of feed used.

Poultry derive part of their feed directly from plant sources and part indirectly through animal sources.

Feeds may be classified into five principal groups, depending upon the primary purposes for which they are fed. These groups are carbohydrate, protein, mineral, fats, and vitamin feeds.

Carbohydrate Feeds

Carbohydrate feeds constitute about 70 to 80 per cent of poultry rations. They are used primarily for heat, energy, and fat production. The carbohydrate feeds are produced easily, are readily available, and are cheap. They contain other nutrients in addition to carbohydrates or nitrogen-free extract (Tables 1–3, Appendix). They are deficient in certain essential amino acids, minerals, and vitamins.

The cereal grains are the chief carbohydrate feeds. They are much alike in composition and feeding value. The amounts of different grains in rations may be varied within wide limits, depending upon price and availability. Grains are graded according to moisture content, weight per bushel, soundness of kernels, and freedom from foreign seeds and dirt.

Corn. Indian corn, or maize, is the chief cereal grain produced in the United States. It produces better yields than the other grains, is easily grown, and is well liked by domestic animals. Corn is high in nitrogen-free extract, chiefly starch, and relatively high among the cereal grains in fat. It is low in protein and mineral content. The two chief types of corn fed to livestock are dent and flint. They have about the same feeding value. Flint corn is harder than dent corn. Hybrid corn has largely replaced open-pollinated corn because of greater yield. However, its protein content is lower.

New corn that is well matured at husking time, should not contain more than 20 or 25 per cent moisture. It is satisfactory for poultry-feeding purposes as soon as it is dry enough to shell. The feeding value of new corn per pound as purchased becomes greater as it becomes drier.

Shelled corn may spoil, when stored, if it contains more than 14 to 15 per cent water.

Ground corn generally has about the same feeding value as whole corn. Some of the whole corn is used by the animal for energy for grinding, thereby lowering its net feeding value Ground corn has a tendency to dry out and become unpalatable The fat in the germ becomes rancid and there is loss of vitamin A These factors reduce the net value of ground corn. Coarsely ground corn is more palatable and gives better results than finely ground material. The feeding value of ground corn is also higher when it is ground only a few days before it is to be fed.

Wheat. Wheat is second only to corn as a cereal in the United States. It is raised primarily for the manufacture of flour and other human foods It is generally more expensive than corn and other cereal grains, and is therefore

less used in livestock rations. Wheat by-products, bran and middlings, resulting from the manufacture of flour, are widely used in livestock and poultry rations. Wheat from the western plains contains about 13.5 per cent protein, while that from the Pacific Coast has only 9.9 per cent. Spring wheat is slightly higher in protein and fiber than winter wheat. Wheat is low in calcium, but is a fairly good source of phosphorus. It is a good source of vitamins B_1 and E. Winter and spring wheat have about the same feeding value.

Whole wheat is the most palatable of all the grains for poultry. Young chicks are able to eat and utilize it after they are two or three weeks old. Good, sound, and clean whole wheat is usually worth more for flour milling purposes than for livestock feeding. Shriveled wheat that is unsatisfactory for milling purposes is satisfactory for poultry feeding. The same is true of wheat that contains other grains and possibly some weed seeds. Wheat gives better results when fed as the whole grain in feeders than when ground and mixed in the mash.

Wheat bran is a by-product obtained in the milling of wheat for flour. It is the outer coating of the wheat grain. Bran contains about 16 per cent protein, 5 per cent fat, and 10 per cent fiber. It is low in calcium, but contains more phosphorus than any of the other grain products. Bran should not constitute more than 5 to 10 per cent of the chick ration because of its bulkiness, high fiber content, phosphorus content, and laxative effect. The best grades of bran have large clean flakes and contain no screenings. Fine, reground bran or standard bran often contains screenings. These screenings are chiefly weed seeds. They may interfere with palatability, depending upon the kind and amount of seeds present. Bran is used in rations primarily to add bulk and for its mild laxative effect.

Wheat middlings consist of fine particles of bran and germ and red dog flour obtained as a by-product in the milling of wheat for flour. This feed consists of 17.4 per cent protein, 6.8 per cent fiber, and 5.5 per cent fat. It supplies about 12 per cent more digestible nutrients than bran and is a better feed. It adds to the palatability of the mash, supplies B_1, E, and other vitamins through its germ content.

Wheat mixed feed, also known as "mill run," consists of the bran and middlings obtained in the milling of wheat. It has about the same feeding value as equal parts of bran and middlings and may be used in place of them in poultry rations.

Oats. Oats rank third in acreage among the cereals in the United States. They contain about 12 per cent protein, 10.6 per cent fiber, and 4.7 per cent fat. Oats vary all the way from 30 per cent hulls or less and thirty-two pounds or more per bushel to more than 50 per cent hulls and less than twenty-five pounds per bushel. Good quality heavy oats weighing thirty-two pounds or more per bushel are a valuable feed for poultry.

Whole oats are a satisfactory feed for poultry. They can be utilized satisfactorily by chickens and turkeys which are at least six weeks old. The consumption will vary with the environment and other constituents in the ration.

Chickens kept in confinement and on wire will consume more oats than birds kept on straw litter and given green grass range. Oats may be kept before the birds in hoppers or mixed with other grains or the mash.

Ground oats are used satisfactorily in mash feeds. They should be finely ground with a hammer mill.

Clipped oats have been run through an oat clipper, which clips off the pointed end of the hulls. This process is unnecessary.

Hulled oats, also known as oat groats, and rolled oats are of less value than whole or ground oats for poultry. While hulled oats contain less fiber and more digestible nutrients than ground whole oats, they contain less of the factors which prevent cannibalism and perosis. It is not economical to feed hulled oats to poultry.

Sprouted oats have less energy value than unsprouted whole oats. They were once used as a substitute for green grass and succulent feed during the winter months.

Barley. Barley ranks fourth in importance as a grain crop in the United States. It is the most widely cultivated of the cereals throughout the world, as it is adapted to a wide range of climatic conditions. Barley production is gradually replacing oat production. The two grains are much alike in composition and feeding value. Heavy barley, weighing forty-eight pounds or more per bushel, is more satisfactory for poultry feeding than lighter barley weighing only about forty-five pounds per bushel. Barley may be used in the same manner as oats in poultry rations. It may be used to replace oats or a part of the corn and wheat products commonly used in poultry rations. Its feeding value may be improved by soaking in water or the addition of enzymes, in some cases.

Rye. Rye, although resembling wheat closely in composition, is an unsatisfactory feed for poultry. The whole grain is hard and unpalatable. The use of 20 per cent or more of ground rye in chick rations causes digestive disturbances and the droppings have a tendency to adhere to the feet. A small amount of rye, not exceeding about 15 per cent, may be used in growing and laying rations. It should be ground and used in the mash feed.

Buckwheat. Buckwheat is unpalatable because of its dark, unattractive appearance and high fiber content. It is unsatisfactory as a whole grain feed. Ground buckwheat or buckwheat middlings may be used to replace 10 to 20 per cent of other grains or their by-products in poultry mash feeds.

Sorghum grains. Sorghum grains are grown in the southwestern part of the United States where there is a scarcity of rainfall. The chief kinds are milo, kafir, feterita, kaoliang, hegari, durra, and shallu. The sorghums resemble corn in composition (Table 2, Appendix). Unlike yellow corn, they are deficient in vitamin A. There are no advantages in including sorghum grains in poultry rations unless they are cheaper than corn, wheat, and oats. In fact, the sorghum grains do not give quite so satisfactory results.

Rice. Rice is one of the most important cereal crops of the world. However, the production in the United States is of minor importance. Rice is grown in the coastal section of Louisiana, and in Arkansas, Texas, and California.

Rice products, such as rice bran, rice polish, and brewers' rice, can be used to replace part of the other grains in the ration. Rice is a good feed and well liked by poultry. It is seldom economical for use in rations except in regions where it is produced.

Cane molasses. Cane molasses, also known as blackstrap, is a by-product of the manufacture of cane sugar from sugar cane. Cane molasses may be used to replace cereal grains, pound for pound, up to 10 per cent of the ration. It should be incorporated in the mash feed with a power mixer. Cane molasses used in rations containing little or no milk will increase palatability, increase water consumption, and serve as a mild laxative.

Beet molasses is not as satisfactory as cane molasses because of its higher alkaline salt content and greater laxative effect.

Bread. Bread and other stale bakery products are sometimes fed to poultry. The analysis of bread is quite similar to that of grains (Table 1, Appendix). Bakery products may be used to replace a part of the grains fed to poultry.

Potatoes. Potatoes which are too small for sale may be cooked and fed to poultry. A gallon of cooked potatoes may be fed to one hundred hens daily to take the place of about a quart of grain.

Fat Feeds

Fats provide a concentrated source of energy for poultry rations (p. 225). They are generally added at 2 to 5 per cent levels. Fats reduce dust, improve appearance, texture, palatability, and feed efficiency for both growth and egg production. In recent years, fats have gained popularity as poultry rations because they have become less expensive and their stability has been improved by the incorporation of small amounts of antioxidants (p. 234).

Oils from seeds, chiefly soybean oil, peanut oil, cottonseed oil, corn oil, and wheat germ oil, promote chick growth by supplying energy and essential unsaturated fatty acids which the chick is unable to synthesize.

Lard, which has been stabilized with an antioxidant, is utilized about as efficiently by the chick as the vegetable oils (Table 8–3).

Table 8–3

METABOLIZABLE ENERGY VALUES AND UTILIZATION OF FATS AND FATTY ACIDS [a]

Product	Metabolizable Energy Cal./Lb.	Utilization Per Cent
Corn oil	3950	92.9
Degummed soybean oil	4210	98.8
Lard	3980	93.4
Hydrogenated fat	3250	76.6
Feed grade tallow	2990	70.3
Hydrolized fat	3230	77.8
Menhaden oil	3700	87.8

[a] Renner and Hill.

Beef tallow is not metabolized as well as lard or the unsaturated vegetable oils.

Hydrogenated fats are utilized about as efficiently as tallow and less efficiently than the unsaturated vegetable oils from which they are produced.

Fats for animal feeding purposes must be free from fat soluble toxic impurities or decomposition products. Those commonly added to poultry rations are of animal origin and are obtained by the rendering of animal tissues. Feed grade animal fats should be labeled according to sources as lard, tallow, etc. They should contain less than 2 per cent moisture, not more than 15 per cent free fatty acids, solidify at 40° C. or higher, and contain an approved kind and amount of antioxidant to provide stability.

Protein Feeds

The protein feeds are the most costly group of feeds used in poultry rations. They generally constitute from 10 to 40 per cent of the ration. Protein feeds are derived from both plant and animal sources. Care is needed in the selection of protein feeds for poultry rations in order to secure a sufficient quantity of the essential amino acids for growth and egg production (Table 8–2).

Animal protein feeds include milk, meat scraps, tankage, fish meal, and hatchery residue. They are more palatable, higher in mineral, vitamin B_{12} and riboflavin content, and higher in biological value than vegetable proteins. Most animal protein feeds are more variable in composition than vegetable protein feeds, because they are blends of various packing house and cannery by-products. The use of high temperatures in the preparation of animal protein feeds reduces their digestibility, vitamin content, and biological value.

Vegetable protein feeds include soybean oil meal, corn-gluten meal, cottonseed meal, peanut oil meal, and linseed meal. They are not so palatable or digestible, or of so high a biological value as the animal protein feeds. Vegetable protein feeds are low in riboflavin and vitamin B_{12} content. Cooking under pressure, in the process of removing oil, increases their feeding value.

Milk is a good protein feed for poultry, but it is usually too expensive to use for this purpose. It furnishes a good assortment of amino acids, minerals, and vitamins.

Skim milk and buttermilk have nearly the same value as whole milk yet are much cheaper for feeding to poultry. If chickens are given milk to drink in place of water, feed consumption will be reduced about 13 per cent.

Condensed milk, also known as a semisolid milk, usually contains 26 to 30 per cent solids and 70 to 74 per cent water.

Dried milk (skim milk and buttermilk), if properly prepared and not overheated, has about the same feed value as the liquid and condensed forms when compared on the same solids basis. A gallon of liquid skim milk or buttermilk is equal to about three pounds of the condensed or 0.9 pounds of the dried form in feeding value.

Meat scraps. Meat scraps are composed of the ground, dry-rendered resi-

due from animal tissues exclusive of hoof, horn, manure, and stomach contents, except in such traces as might occur unavoidably in good factory practice. It varies widely in composition and feeding value, depending on the amount of bone, cracklings, glandular tissue, and meat present. The more bone present, the higher the mineral content and the lower the protein content. The vitamin content is largely determined by the amount of glandular tissues present, such as livers and kidneys, and the temperature used in the process of preparation. Meat scraps are widely used in poultry rations to supply protein and minerals. Products with high bone content are known as meat and bone scrap.

Tankage. Tankage is a packing house by-product somewhat similar to meat scraps. It generally contains 60 per cent protein, while meat scraps generally contain 50 per cent. Tankage may be prepared by cooking under live steam or by the dry-rendering process. The latter process produces a product of higher nutritive value. "Stick," or the cooking water residue, and blood meal are often added to raise the protein content to 60 per cent. Both of these products are of low biological value. Therefore, tankage is of lower nutritive value than meat scraps and seldom used in poultry rations.

Fish meal. Fish meal is the clean, dried, ground tissue of undecomposed whole fish or fish cuttings, either or both, with or without the extraction of part of the oil, and containing not more than 3 per cent salt. Fish meals vary in composition and feeding value. Those made from white fish are superior to those made from dark, inedible fish. Fish meals made at low temperatures are superior to those processed at high temperatures. Fish meals containing much of the viscera, as are obtainable from some fish canneries, are superior to meals made from whole fish. The average fish meal has about the same composition and feeding value as meat scraps. In coastal regions, fish meal is as cheap or cheaper than meat scraps. Inland it is more expensive. White fish meal made by a low temperature or vacuum process contains protein of high biological value and is a good source of riboflavin. It compares favorably with milk as an animal protein feed.

Poultry by-product meals. The inedible by-products from poultry dressing plants, exclusive of feathers, may be processed into meal and used as a substitute for part of the animal or vegetable protein feeds generally used in poultry rations (Table 1, Appendix). The products supply an unknown factor, also supplied by fish solubles, for growth and hatchability (p. 232).

Feather meal is a rich source of protein (86 to 88 per cent) but is deficient in the essential amino acids histidine, lysine, methionine, and tryptophan It may contain an unknown factor for growth and hatchability. Feather meal may be used to replace 10 to 20 per cent of the other protein feeds in broiler and laying rations.

Offal (by-product meal) is made from the heads, feet, intestines, and reproductive organs obtained from poultry processing plants. It contains about 55 per cent protein. Poultry offal meal may be used to replace about 20 per cent of the other protein feeds commonly used in poultry rations.

Poultry blood meal contains about 65 per cent protein. It may be produced

separately or in combination with offal meal and used in a similar manner as a substitute for part of the other protein feeds.

Hatchery residue. Hatchery residue, also known as chicken tankage, consists of infertile eggs, dead embryos, cull chicks, and eggshells obtained in hatchery operation. Most of the material is a total loss at the present time. It may be processed like meat scraps. Chicken tankage is a satisfactory animal protein feed for poultry. It may be used in the place of meat scraps in laying rations.

Blood meal. Blood meal is a poor protein feed for poultry. It is unpalatable and its protein is of low biological value.

Soybean oil meal. Soybean oil meal is the most widely used of all the vegetable protein feedstuffs. It is prepared from soybeans by removing the oil and grinding the resulting presscake. Soybeans are unpalatable and unsatisfactory as feed. Soybean oil meal is palatable and a good protein feed when supplemented with minerals and vitamins B_{12} and riboflavin. Soybean oil is used in industry. A ton of beans will yield about 1600 pounds of soybean oil meal and 400 pounds of oil. The beans may be processed by the expeller, hydraulic, or solvent methods. In the expeller method, the crushed beans are subjected to great pressure in "expellers" to remove the oil. Some heat is generated in the process. In the hydraulic or old process, the beans are cooked and most of the oil pressed out in hydraulic presses. This method is the one generally used in processing cottonseed and flaxseed. In the solvent process, the ground beans are extracted with low-boiling-point gasoline. The solvent is later removed by treatment with steam, which also cooks the feed. Soybean oil meal made by this process contains about 44 per cent protein and 1 per cent fat, while that made by the hydraulic process contains about 41 per cent protein and 5 or 6 per cent fat. A higher protein content (50 per cent) meal may be produced by removing the hulls.

Soybean oil meal for poultry rations should have been thoroughly cooked while being processed. This is indicated by a pleasant nutlike taste and a light brownish or tan color. If the soybean oil meal has a raw "beany" taste, it has not been heated sufficiently. When soybean meal replaces most of the meat scraps or fish meal in poultry rations, an additional quantity of minerals, methionine (p. 253), and vitamins B_{12} and riboflavin need to be included in the ration. A pound of mineral mixture (p. 254) is generally added to the ration for each 5 or 6 pounds of soybean oil meal used when animal protein feed constitute less than 50 per cent of the total protein feeds used.

Corn gluten meal. Corn gluten meal is that part of shelled corn that remains after the separation of the larger part of the starch, the germ, and the bran, by the process employed in the manufacture of corn starch and glucose. It is a good protein feed, but like other grain proteins is deficient in essential amino acids. Like soybean oil meal, it should be fed with animal protein feeds and minerals. Corn gluten meal made from yellow corn contains about twice as much vitamin A as yellow corn.

Cottonseed meal. Cottonseed meal is a cheap and satisfactory protein feed for poultry rations in the cotton-producing states. It must be supplemented

with animal protein, minerals, vitamins B_{12} and riboflavin, methionine, and lysine, as in the case of soybean meal (p. 252). The use of more than 5 or 6 per cent cottonseed meal in laying rations results in the production of eggs which develop green and brown spots on the yolks, when the eggs are held more than a few weeks in storage.

Distillers' dried grains. Distillers' dried grains are of variable composition because of the variation in grain mixtures used by different distilleries. The protein content varies from 15 to 30 per cent, and the fiber from 10 to 15 per cent. This feed is little used in poultry rations.

Linseed oil meal. Linseed oil meal is made from flaxseed. The production in the United States is small. Linseed oil meal is not so palatable as soybean oil meal or corn gluten meal. There is no advantage in including it in poultry rations when the more palatable protein feeds are available.

Peanut oil meal. Peanut oil meal is a good vegetable protein feed. The quantity produced is small. It may be used economically in poultry rations in the few southern states where peanuts are produced.

DL- methionine is an essential sulfur-containing amino acid used as a supplement in rations containing soybean oil meal as the principal protein (Table 8–2). The analog, methionine hydrox analog calcium is about as effective as a supplement and at present is cheaper. Either product may be added at 0.05% level to high energy broiler rations in which most of the protein is supplied by soybean oil meal. It should be premixed before incorporation in the ration (p. 233).

Lysine is an essential amino acid. A deficiency may interfere with normal feather growth and pigmentation, especially in turkeys. Lysine is a good amino acid, along with methionine, for supplementing cottonseed meal (Table 8–2).

Calcium sources. *Limestone,* which is largely calcium carbonate ($CaCO_3$), is generally used in the ground form as a cheap and satisfactory source of calcium in mash feed. It may also be used in the form of grit as a source of calcium for egg production. A suitable limestone should contain not less than 35 per cent calcium and not more than 3 per cent magnesium.

Oyster shells contain somewhat more calcium carbonate content (96 per cent or more) than most limestone and they are freer of impurities. Hens prefer them to limestone grit when fed free choice in grit hoppers.

Clam shells may be used as a substitute for oyster shells although they are not quite as satisfactory.

Phosphorus sources also supply some calcium.

Phosphorus sources. *Bone meal,* which is largely tricalcium phosphate $(Ca_3PO_4)_2$ was formerly used as the principal source of phosphorus. With the growth of the poultry industry and the increased scarcity of bones for making bone meal, phosphatic rocks are now being used. They should contain less than 0.5 per cent fluorine, because more than trace amounts of this element in poultry rations interferes with normal mineral assimilation. Choice of phosphorus source should be determined by price, availability, and biological value.

Defluorinated rock phosphate is widely used as a source of phosphorus in poultry rations. It should contain 31 per cent calcium, 14 per cent phosphorus, and 0.5 per cent or less fluorine.

Dicalcium phosphate contains 18.5 per cent phosphorus and 24 per cent calcium. It is used extensively in commercial mixed feeds.

Low fluorine rock phosphate and other phosphorus compounds may be used.

Mineral Feeds

Growing birds need minerals for growth of skeleton and the laying hens need minerals for the formation of the egg yolks and eggshells. Most of the feeds used in poultry rations are low in mineral content. This is true of the grains and vegetable protein feeds. Animal protein feeds are good sources of minerals. When little or no animal protein feed is included in poultry rations, additional minerals must be added. Calcium, phosphorus, manganese, sodium, and chlorine are the mineral elements most likely to be deficient in feed comprising poultry rations. The laying hen has an exceptionally high requirement for calcium for making eggshells.

Salt. Salt, or sodium chloride ($NaCl$), is needed in poultry rations for palatability and digestion. Salt is deficient in grains and vegetable protein feeds. Meat scraps and milk contain salt because the mineral is fed to animals from which they are obtained. Fish meal is also a good source. Salt is generally added to poultry rations at the rate of 0.5 per cent.

Manganese. It has been shown that manganese is an essential mineral element for bone formation and hatchability. Only about fifty parts per million are needed in the ration. It may be supplied by the proper selection of feed (Table 1, Appendix). Manganese may be added to mash feeds or mineral mixtures in the form of manganese sulphate or carbonate.

Iron. Only a very small amount of iron is needed in poultry rations. It is supplied by a number of feeds used in poultry rations, such as meat scraps, fish meal, alfalfa, and grass. A small amount of iron is usually added to mineral mixtures in the form of iron oxide, chloride, or sulphate.

Iodine. A very small quantity of iodine is needed in poultry rations. Ample amounts are provided by the use of marine products, such as fish meal, oyster shells, or fish oil. Iodized salt is sometimes used in poultry rations. Iodine is generally added to mineral mixtures in the form of potassium iodide (KI).

Mineral mixtures. Mineral additions are necessary in rations that contain little or no animal protein It is often desirable to mix the minerals together and incorporate the mixture in the mash feed. It is difficult or impossible to mix thoroughly a minute quantity of a mineral in a big pile of feed. A satisfactory mineral mixture consists of:

Bone meal, 26 97; limestone, 50, salt, 20; ferrous sulphate, 2; potassium iodide, .02; copper sulphate, .01, and manganese sulphate, 1 per cent.

Grit. The term "grit" is usually intended to refer to hard, insoluble minerals, such as mica. Limestone and oyster shells are also referred to as grit

There are those who hold that hard, insoluble grit is necessary or desirable for aiding the gizzard in grinding feed. Others believe that hard grit is unnecessary in the ration of poultry, maintaining that oyster shell and limestone grit will serve for grinding purposes and at the same time provide needed calcium. It is the opinion of the authors that hard, insoluble grit is not necessary in poultry rations. There is no objection to putting out mica or other hard, insoluble grit along with limestone or oyster shell grit in separate containers. Birds should not be forced to eat grit by placing it on top of the feed. A sack of hard, insoluble grit will last a flock of birds a long time if limestone and oyster shells are kept available.

Vitamin Feeds

Many of the feeds used in poultry rations are good sources of more than one group of nutrients. In this chapter the feeds have been classified according to the primary purpose for which they are fed. Some of the following feeds classed as vitamin feeds are also good sources of proteins and minerals.

Green grass. Young, tender, green grass supplies most of the vitamins needed by chickens except vitamin D. When the birds are on range they will secure this vitamin from sunlight. Grass also supplies protein, minerals, and carbohydrates needed by poultry. Less expensive feed and a smaller amount are needed by poultry when they are kept on young, tender, green grass range. Unfortunately, suitable range is generally available only during the spring and early summer months. As the season advances and the grass becomes older, the protein, mineral, and vitamin content declines rapidly and the fiber content increases. By pasturing the range closely or by making frequent cuttings of the grass, and by irrigation, it is possible to maintain suitable pasture for poultry. Alfalfa or ladino clover range may be used to supply green feed throughout the summer and fall.

Layers given green grass range produce eggs of lower market quality than birds kept in confinement. The yolks have a darker yellow color and the whites are more watery. While such eggs are of lower value from the standpoint of market grade, they are of greater food value because of the higher vitamin A, D, and riboflavin content.

Alfalfa. Dehydrated alfalfa, third cutting, hay or leaf meal is included in some poultry rations to supply vitamin A and riboflavin. It also supplies vitamin E, vitamin K, minerals, and protein. Leaf meal is better than the hay because of its greater nutrient content (Table 1, Appendix). Dehydrated alfalfa meal is better than the sun-cured products because of its higher vitamin content (Table 1, Appendix). Poultry managers interested in high energy rations, are reducing the alfalfa content to a low level of high quality feed and substituting synthetic forms of vitamin A and riboflavin, because alfalfa meal is not palatable, its vitamins are not stable, and it contains many fibers. A good dehydrated alfalfa meal should contain 100,000 I.U. of vitamin A activity per pound.

Fish oils. Fish oils, such as cod, sardine, pilchard, salmon, tuna, menhaden, and herring were used for a number of years after the discovery of vitamins

A and D, as a commercial source of these vitamins. Since the oils lack stability, are difficult to transport and incorporate in feeds and may impart a fishy taste to the eggs or meat, they are being fortified with or replaced by synthetic vitamin A and irradiated animal sterols as a source of vitamin D. Fish oils should be purchased on their guaranteed vitamin content rather than price per pound or gallon. A satisfactory fish oil should contain at least 600 U. S. P. units of vitamin A and 85 I. C. U. units of vitamin D_3 per gram. To determine the vitamin content per pound, multiply the content per gram by 454, since there are approximately this number of grams in a pound. Fish oil should be premixed before being added to a batch mix of mash ingredients (p. 233).

Whey. Dried whey, a by-product of the manufacture of cheese, is a good source of vitamin G. It contains about 1.5 times the amount found in milk. It may be used as a substitute for dried milk in poultry rations, using two-thirds as much whey as milk and making up the difference with soybean oil meal or some other protein feed. The riboflavin and unidentified factor content of whey is further concentrated in some products by removing the lactose and some of the minerals. The concentrated product is mixed with soybean meal and other products and sold as a vitamin concentrate under various trade names.

Liver meal. Pork liver is an excellent source of riboflavin and other vitamins of the B complex. Liver meal from other sources is of lower vitamin potency. The method of production of liver meal also affects its vitamin potency. There is a very limited amount of high-quality liver meal available for use in poultry rations.

Fish solubles. Condensed fish solubles are obtained by condensing the water resulting from the hydraulic extraction of oil from fish. They are a good source of B-complex vitamins including B_{12} and an unidentified factor.

Yeast. Yeast is an excellent source of vitamins B_1 and riboflavin, and irradiated yeast is also a good source of vitamin D_2. It is usually more economical to supply the vitamin needs of poultry by the proper selection of feed for the ration than to add yeast. The vitamin content of yeast varies within wide limits, depending on the kind of yeast, the method of production, and the purity of the product.

Distillers' solubles. Distillers' solubles and distillers' grains with solubles are good sources of riboflavin and other B-complex vitamins. They also contain 25 per cent or more protein, some minerals, and other nutrients. They may be used to replace milk products, liver meal, alfalfa, or yeast as a source of riboflavin and other B-complex vitamins. Distillery by-products may be fed in amounts up to 10 per cent of the ration.

Sunlight. Sunlight supplies the vitamin D factor needed by poultry by its effect on cholesterol in the skin of the bird. Exposure of the skin to ultraviolet rays of sunlight gives its cholesterol vitamin D properties. Summer sunlight is more powerful than winter sunlight. The chicken receives the beneficial rays of sunlight through the skin of the face and comb. Feathers shut out the ultraviolet rays. The amount of exposure to sunlight needed will depend

on the kind of poultry, the purpose for which they are kept, the season of the year, the ration fed, and the locality in which the birds are kept. The amount of sunlight needed daily will vary from about five minutes to about five hours. Breeding hens will need more sunlight than chicks. Clouds, smoke, and fog shut out some of the ultraviolet rays of sunlight and reduce its efficiency.

Vitamin A supplements. Rations deficient in vitamin A may be supplemented with vitamin A mixtures. These are usually a premix of vitamin A acetate or palmitate. They vary widely in vitamin A potency, from about 5,000 to more than 300,000 I.U. per gram. High potency products should be further premixed before additions to feed mixtures (p. 233). Vitamin A feed mixtures should be stabilized with an antioxidant to retard loss of vitamin A potency (p. 234).

Vitamin D supplements. Irradiated animal sterols are better sources of vitamin D for poultry than those of plant origin (p. 230). They are available in premixes which vary widely in potency. Products containing 1,500 or more units per gram are generally purchased as premixes for further pre-mixing before incorporation in poultry rations (p. 233).

Vitamin E supplements. Some rations, especially for turkeys need additional vitamin E (Table 13–6). This may be supplied by natural vitamin E concentrates or dl-alpha tocopheryl acetate premixes. They vary widely in potency. One premix sold on the market contains 20,000 I.U. of vitamin E per pound (44 per gram).

Riboflavin supplements. Riboflavin is premixed with a carrier and sold in mixtures of varying potency. One product available on the market contains 16 grams of riboflavin per pound (35 milligrams per gram.) Riboflavin mixtures should be premixed again before incorporation in large batch mixes.

Pantothenic acid supplements. D- calcium pantothenate, or other complexes of this salt, are available as premixes. One common mixture contains 32 grams of D- calcium pantothenate per pound (70 milligrams per pound). It should be further premixed before mixing with rations.

Niacin supplement. Nicotinic acid (U.S.P.) without a carrier may be purchased. It should be premixed before use.

Vitamin B_{12} supplements. Premixes sold as vitamin B_{12} supplements vary widely in potency. A common potency is 12 milligrams of vitamin B_{12} per pound. It needs further premixing before use in batch mixes.

Choline supplement. Choline is generally supplied in the form of choline chloride premixes. A common one contains 113.5 grams of choline chloride per pound (250 milligrams per gram).

Vitamin K supplement. This vitamin may be needed in some modern high energy rations largely of plant origin. An additional amount may be supplied through the use of menadione or menadione sodium bisulfite premixes. They should be further premixed before use in rations.

Antibiotic supplements. Antibiotics are sold on the market as premixes, for use in poultry rations.

Procaine penicillin supplement is available in the potency of 4 grams of procaine penicillin per pound.

Terramycin supplement (TM-10) is available in a potency of 10 grams of oxytelracycline per pound.

Aureomycin supplement (*Aurofac-10*) is available in a potency of 10 grams of chlortetracycline per pound.

Bacitracin supplement (*Baciferm-10*) is available in a potency of 10 grams of bacitracin per pound.

Streptomycin supplement is available in a potency of 10 grams per pound.

Combinations of antibiotic mixtures are also available as feed supplements.

Formulating Rations

When the nutritive requirements of poultry and the nutritive value of feeds are known, it is a comparatively simple task to formulate poultry rations. Since there are many poultry feeds, an unlimited number of satisfactory rations may be formulated. In choosing a ration for a given purpose, one should keep in mind the nutritive requirements, the available feeds, their supplementary value when fed in combinations, the price, and the system of feeding to be used. Nearly every feeder has a different set of conditions. A suitable and economical ration for one farmer may not be the most economical for his neighbor. The feeds available on the farm or in the community are important in determining the ration and system of feeding that should be used on any given farm.

Price and availability of ingredients. The price and availability of ingredients will have a marked influence on the choice of feeds.

The *carbohydrate feeds* are abundant and cheap. The price is generally lowest about harvest time and increases slightly during the year. In the Corn Belt, more corn is used than any of the other cereals in poultry rations. In the Northwest, wheat and its by-products are plentiful and are used in larger amounts than in other parts of the country. In the Southwest, the sorghum grains grow well and are used to replace part of the cereal grains generally used in poultry rations. In some of the northern states barley is used in place of most of the corn because it grows well and because the season is too short for corn. These and other available facts illustrate that the carbohydrate feedstuffs may be varied within wide limits, depending on price and availability.

The *protein feeds*, especially the animal protein feeds, are expensive. Dried milk is the most expensive of the group. Soybean oil meal is the cheapest. There is a supplementary effect among the animal and vegetable protein feeds (Table 8–2). The economical procedure is to use as much vegetable protein feeds and as little animal protein feeds as possible without lowering the value of the ration. There is often a tendency to feed too little protein and too much grain because of difference in price and availability.

The *mineral feeds* are cheap and readily available. The fowl can use only a limited amount of minerals. There is often a tendency to use too much minerals, especially limestone, in poultry rations because they are cheap.

The *vitamin feeds* are generally expensive. Fortunately only small amounts are used. Fish oil, milk, and dehydrated alfalfa leaf meal were once the chief

products used. Single vitamins such as synthetic vitamin A, irradiated animal sterol, riboflavin, and vitamin B_{12} are now being added to replace these feeds. They are used in rations for confined birds to take the place of green grass range and sunlight. Rations may be cheapened by providing birds with green grass range and replacing the oil and alfalfa by one of the cereal grains and part of the milk by one of the cheaper protein feeds.

Selection and balance of ingredients. The number of ingredients used in a ration is not a true measure of the value of the ration. Simple rations, consisting of six or eight ingredients, are often as valuable or even more so than complex rations consisting of a dozen or more ingredients. It is true that variety adds to palatability and increases the chances of making good the deficiencies found in certain feeds, provided the materials chosen are palatable and have a supplementary effect. For instance, a grain mixture of corn, wheat, and oats is not improved by adding barley, buckwheat, and rye to it. These latter grains are not so palatable and do not supply anything not supplied by corn, wheat, and oats.

The *carbohydrate feeds* generally constitute 40 to 80 per cent of the poultry ration. It is advisable to use at least three cereal grains and by-products in the ration. Corn, oats, and wheat or wheat by-products are the ones generally used.

The *protein feeds* generally constitute from 10 to 40 per cent of the ration, depending on the age of the bird. Meat scraps or fish meal, milk, and soybean oil meal are the ones most generally used.

The *mineral feeds* are supplied by the use of animal protein feeds, such as meat scraps and milk. Salt is generally added to the ration at a 0.5 per cent level. Oyster shells are kept available for laying birds.

Vitamin feeds and supplements are fed to birds in confinement to supply vitamins obtained by birds on green grass range.

Methods of Feeding

Having selected the feeds and amounts to be used, there are several satisfactory ways of feeding them to poultry. These include free choice of mash concentrate and grains, mash and limited grains, and all-mash.

Free choice of mash supplement and grains. Mash protein concentrates or supplements varying from about 24 to 32 per cent protein content are available for feeding free choice with grains or for mixing with grains to make a mash feed to be fed with limited grains or to be used as an all-mash feed. If the mash feed is palatable, it gives very good results when fed free choice with grains. The birds have an opportunity to balance the protein, and, to a certain extent, their vitamin needs in accordance with the rate of production. Birds in high production and pullet layers will eat more mash and less grain than old hens or birds in low production.

The free choice of mash concentrate and grain system of feeding eliminates the grinding and mixing of about 67 to 79 per cent of the ration. The mash may be used as an all-mash turkey starter or mixed with about an equal

amount of corn meal to make an all-mash chick starting and growing ration. This mash may serve as an all-purpose poultry mash feed.

The free choice of mash concentrate and grain system of feeding permits the birds to balance their own ration and therefore simplifies the poultry feeding problems. It is economical and adaptable to the feeding of all kinds of poultry.

Mash and limited grains. One of the most widely used systems of feeding layers during the past several years has been the feeding of about an 18 to 20 per cent protein mash feed and limited grain. The mash feed is kept before the birds all the time and about an equal amount of grain is fed. The birds are given about as much grain as they will clean up, late in the afternoon. The grain mixture generally consists of corn, wheat, and oats.

The mash and limited grain ration requires the grinding and mixing of about 50 per cent of the ration. It requires a good knowledge of poultry feeding. Otherwise, the feeder may feed too much grain for satisfactory growth or egg production.

All-mash. In the all-mash system of feeding, all of the feeds eaten are ground, mixed, and fed as a single mixture. The ration is based on the requirements of the birds that need the most nutrients. There is no chance for the birds to vary their diet according to likes or needs. This system of feeding requires the grinding and mixing of all the ration. Ground feeds are not so palatable and do not retain their nutritive value so well as unground feeds.

The all-mash system of feeding is desirable for starting and growing chicks because it involves less labor. When the birds become older, the feed consumption much greater, and the individual needs more pronounced, one of the grain-and-mash systems of feeding may be more economical.

The all-mash system of feeding is desirable in nutritional experimental work where the consumption of ingredients should be kept in constant ratio. It is also satisfactory in battery and automatic feeding of birds, where feeding space is at a premium. The all-mash system of feeding results in the production of eggs of more uniform yolk color and white consistency. However, even on the same ration the eggs from different individuals vary within wide limits as regards internal appearance.

Pellets. Mash feed is now on the market in the form of pellets. It is forced through a press under high pressure and formed into pellets of varying size. Pellets may be more palatable than some finely ground mash feeds. There may be some advantage in feeding pellets in range feeders, where the wind may blow away part of the ground mash feed. The keeping quality of nutrients in the form of pellets may be better than in the form of finely ground mash feed. Feed in the form of crumbles is also available. Preparation of mash feed in the form of pellets adds to the cost of preparation.

Artificial lights. Feeding for early rapid growth and fall egg production of hens is closely connected with the use of artificial light. It is used to lengthen the day to at least thirteen or fourteen hours, or even to a period of continuous lighting.

Chicks make faster early growth when all-night light is used. It therefore

has a place in broiler production. The presence of light at night in the brooder house or battery room results in more comfort of the birds and less danger of piling. The birds can see to move about and secure feed when needed. A twenty-watt bulb is satisfactory in the ordinary colony brooder house.

Hens may be made to lay more eggs in the late summer, fall, and early winter by the use of artificial light. If lights are used in the fall, spring egg production will be less. Lights have little influence on total yearly egg production. A time switch may be used to turn the lights on about three o'clock in the morning. All-night lights may also be used. A forty-watt bulb is sufficient for a pen that will accommodate about one hundred hens. The light may be suspended over the feeders and water vessel or over the perches.

Artificial lights may be used to help hold up late summer and fall production of yearling hens, shorten the molting period of hens, bring hens into production for winter-hatching eggs, check the neck molt and slump in fall egg production of early-hatched pullets, and hasten the sexual maturity of late-hatched and slow-maturing pullets.

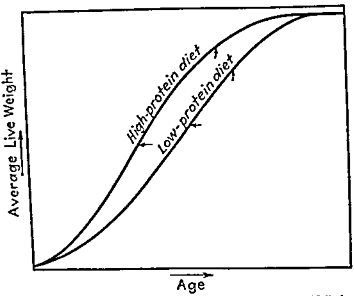
It was formerly believed that the chief benefit derived from the use of artificial lights on layers was to increase the length of day. It was believed that this would result in greater feed and water consumption and consequently greater egg production. Tests conducted at Ohio State University have shown that this is not the principal value of the use of lights. Birds exposed to light at night but deprived of feed and water produced nearly as many eggs on a twelve-hour eating day as birds which had lights and feed and water at night. It is believed that the chief benefit of artificial light in the laying house is to stimulate hormone activity. The pituitary gland is stimulated to secrete a hormone into the blood stream. This is carried to the ovary and stimulates egg production.

Feeding for Maintenance

The nutritive requirements of poultry vary with the purpose for which birds are fed. They include the requirements for maintenance, growth, egg production, hatchability, and fattening.

Nutritive requirements for maintenance. Needs of an animal for maintaining body functions, body temperature, and repair of tissues must be provided before growth, production, fattening, or reproduction can take place. The requirements for maintenance and any one of these other functions are generally listed together. It is not often that poultry are merely maintained for any length of time without some specific object in mind, such as growth or reproduction. Exceptions are male chickens and turkey breeders which may be fed maintenance rations between breeding seasons. Setting hens are also fed maintenance rations while incubating eggs and brooding chicks.

Energy needs for maintenance include those for maintaining body temperature and essential body activities. The temperature of the body of the chicken must be maintained near 107° F. for normal functioning of the body activities. Heat resulting from the heart beat, respiration, digestion, and body movements is used for this purpose. When the heat from these sources



TITUS AND HAMMOND, 1935. REPRODUCED IN "POULTRY HUSBANDRY" BY M. A. JULL BY PERMISSION OF McGRAW HILL BOOK CO., PUBLISHERS

Fig 8–6. Protein level and growth rate. A high protein ration results in early rapid growth, while a low protein ration results in later growth. The horizontal arrows represent changes in growth rates while the vertical arrows represent the approximate age at which production begins.

is insufficient to maintain the normal body temperature, the animal will eat additional food for heat production. In the absence of food, the body will oxidize its own tissues for this purpose. The lower the environmental temperature and the greater the body surface in proportion to body mass, the greater the heat loss from the body and consequently the more food required to maintain the body temperature.

The energy from food required for maintaining body temperature and essential body activities amounts to about 800 calories per square meter of body surface per day. The basal heat production (p. 238) of males is a little greater than that of females, while that of capons is considerably lower. It will vary with the environmental temperature of the bird.

The critical temperature (p. 239) of the chick is 96° F. at hatching time. A seven-degree decrease from the critical temperature results in about 15 per cent increase in metabolism. The critical temperature of the inactive fasting hen is 62° F. The greater the activity of the bird and the greater the amount of food eaten, the lower the critical temperature. The energy needs of moderately active birds are approximately 50 per cent greater than for basal heat production.

The *protein needs for maintenance* are determined by measuring the amount of nitrogen in urine of animals fed a nitrogen-free diet so designed as to furnish all other nutrients in ample amounts. It is usually expressed in terms of milligrams per kilogram of body weight. The endogenous nitrogen (that required for maintenance) amounts to about two milligrams per calorie of heat production. Ackerson and his associates at the Nebraska Agricultural Experiment Station have shown that the nitrogen requirement of young birds is greater per unit of weight than that of old birds. Males probably have a greater nitrogen requirement than females because of the greater basal heat production. Activity should not affect the nitrogen needs for maintenance as long as ample food energy is used to meet the needs for the activity.

The *mineral needs for maintenance* have not been studied so carefully as

the energy and protein needs. The latter two are used up and the by-products excreted. Some of the minerals are used over again and small amounts are excreted when birds are kept on maintenance rations. When sufficient food is supplied to meet the energy and protein needs, it will generally contain sufficient mineral elements to meet the mineral needs for maintenance.

The *vitamin needs for maintenance* have not been carefully investigated. They are lower than for growth or production. Vitamins of the B complex (p. 229) are probably the most essential ones for maintenance.

Feeding for Growth

Growth is the elaboration of new tissues that make up the changes in weight, form, or composition of the animal. The rate of growth is determined by the inherited capacity for growth, the kind and amount of feed consumed, and the environment of the birds. The chicken grows more rapidly than other domestic animals, doubling its weight in less than two weeks and increasing it by ten times in six weeks (Table 8–8 and Fig. 8–4). The absorbed yolk furnishes the first nutrients required by the newly hatched chick. It supplies the energy and other needs until the chick can move about and locate food.

Nutritive requirements. The energy needs for growth include the energy needs for maintenance, activity, and growth of tissue. These needs may be calculated as productive energy or metabolized energy needs (p. 238). The latter is more reliable. Table 8–4 gives the energy content recommended in growing rations. It ranges from about 950 to 1,000 calories of productive energy per pound, for a calorie-protein ratio of about 42 to 45. The energy value of poultry feeds is listed in Table 3, Appendix.

The protein needs for growth are high, since the increase in weight of the growing chicken is largely due to the increase in protein and water. Both the energy and protein content of the ration influence the rate of growth. An animal eats to satisfy its calorie requirements, and it does not consume as much *of a high energy ration as one of lower calorie content. For maximum growth* of poultry, proteins and vitamins must be increased in proportion as the calorie content of the ration is increased.

The large proportion of feed eaten is for energy and a smaller proportion for growth of tissues. As a bird increases in weight and its growth slows, the protein level may be reduced. The percentage of protein needed in a ration for poultry is related to their energy needs. This relationship, termed the calorie-protein ratio, is obtained as follows:

$$\frac{\text{Calories of productive energy per pound}}{\text{Per cent crude protein}} = \frac{\text{Cal.}}{\text{Prot.}}$$

The optimum protein levels for growth and the calorie-protein ratio is listed on Table 8–3.

Not only is it important to have an energy-protein ratio, but poultry must also have a proper assortment and amount of amino acids (Table 8–5). Me-

Table 8–4

ENERGY AND PROTEIN CONTENT OF RATIONS [4]

Type of Ration	Protein Content (Per cent)	Productive Energy: Cal./Lb.	Productive Energy: Cal./Prot.	Metabolizable Energy Cal./Lb.	Metabolizable Energy Cal./Prot.
Chickens					
Starter	21	957	46	1353	64
Grower, free choice	16	945	61	1364	88
Grower, Restricted	16	968	61	1398	87
Layer, floor	16	988	64	1410	91
Layer, cages	16	963	60	1384	87
Breeder	16	962	60	1374	86
Broiler, 0–5 weeks	24	1009	42	1417	59
Broiler, 6–10 weeks	20	1043	53	1467	74
Roaster, 4–5 lbs.	17	1034	61	1463	86
Roaster, 5–7 lbs.	15	1043	70	1489	99
Roaster, 7 lbs. up	14	1057	76	1512	108
Turkeys					
Starter, 0–4 weeks	28	874	31	1205	43
Grower, 5–8 weeks	25	882	35	1233	49
Grower, 9–16 weeks	20	951	49	1348	69
Grower, 17–22 weeks	17	978	56	1389	80
Finisher, 23 weeks up	14	1023	76	1472	109
Broiler, finisher	19	1015	55	1430	77
Breeder, holding	15	804	56	1162	80
Breeder, hatching	16	953	58	1370	83
Geese					
Starter, 0–3 weeks	19	934	49	1337	70
Grower, 4 weeks up	14	977	69	1423	100
Breeder	16	880	56	1276	81
Ducks					
Starter, 0–2 weeks	18	900	50	1298	72
Grower, 3 weeks up	16	920	56	1331	81
Breeder	16	893	56	1305	82

[4] Ontario Agricultural College. Poultry Feed Formulas, 1958.

thionine is probably the first limiting amino acid in growing rations in which the protein is supplied mainly by soybean meal.

The *mineral needs* for growth and bone formation are principally calcium and phosphorus (Table 8–5). The deposit of mineral elements depends on the amounts present, the ratio between them, and the presence of vitamin D. The ration should contain a minimum of 1 per cent calcium and 0.6 per cent phosphorus. The ratio of calcium to phosphorus should be between 1:1 and 2:1.

The sodium chloride or salt requirement is met by the liberal use of animal protein feeds. When these are largely replaced by vegetable protein feeds, it is necessary to add 0.25 to 0.5 per cent salt (Table 8–5). Chickens can tolerate more salt but its use increases water consumption and results in

Table 8–5

NUTRIENT REQUIREMENTS FOR CHICKENS [5]

Nutrients	In Percentage on Amount per Pound of Feed			
	Starting Chickens 0–8 Weeks	Growing Chickens 8–18 Weeks	Laying Hens	Breeding Hens
Total protein, per cent	20	16	15	15
Vitamins				
Vitamin A activity (U.S.P. Units)	1200	1200	2000	2000
Vitamin D (I.C.U.) *	90	90	225	225
Thiamin, mg	0.8	?	?	?
Riboflavin, mg	1.3	0.8	1.0	1.7
Pantothenic acid, mg	4.2	4.2	2.1	4.2
Niacin, mg	12	?	?	?
Pyridoxine, mg	1.3	?	1.3	1.3
Biotin, mg	0.04	?	?	?
Choline, mg	600	?	?	?
Folacin, mg	0.25	?	0.11	0.16
Vitamin B_{12}, mg	0.004	?	?	0.002
Vitamin K, mg	0.18	?	?	?
Minerals				
Calcium, per cent	1	1	2.25	2.25
Phosphorus, per cent †	0.6	0.6	0.6	0.6
Salt, per cent	0.5	0.5	0.5	0.5
Potassium, per cent	0.2	0.16	?	?
Manganese, mg	25	?	?	15
Iodine, mg	0.5	0.2	0.2	0.5
Magnesium, mg	220	?	?	?
Iron, mg	9	?	?	?
Copper, mg	0.9	?	?	?
Amino acids, per cent				
Arginine	1.2	?	?	?
Lysine	0.9	?	0.5	?
Histidine	0.15	?	?	?
Methionine	0.45 ‡	?	0.53	?
Tryptophan	0.2	?	0.15	?
Glycine	1.0	?	?	?
Phenylanine	1.6 §	?	?	?
Leucine	1.4	?	?	?
Isoleucine	0.6	?	?	?
Threonine	0.6	?	?	?
Valine	0.8	?	?	?

[5] National Research Council 1954.
* International Chick Unit.
† About 0.45 per cent from inorganic source.
‡ Cystine may replace about ½ of the methionine.
§ Tyrosine may replace about ⅓ of the phenylanine.

Table 8–6

PRINCIPAL MINERAL AND VITAMIN ALLOWANCES FOR POULTRY MASH FEEDS [6]

	Starter Broiler All-mash	Grower All-mash	Grower Mash with Grain	Layer All-mash	Layer Mash with Grain	Breeder All-mash	Breeder Mash with Grain
Chickens							
Calcium, per cent	1.3	1.3	2*	2*	2.5*	2*	2.5*
Phosphorus, per cent	0.8	0.8	0.9	0.8	1	0.8	1
Manganese, mg./lb.	30	25	50	25	50	25	50
Salt, added per cent	0.25–0.5	0.5	1	0.5	1	0.5	1
Iodine, mg./lb.	0.5	0.5	1	0.5	1	0.5	1
Vitamin A, U.S.P./lb.	4000	4000	5000	4000	6600	4000	7000
Vitamin D, I.C./lb.	340	340	680	400	800	500	1000
Vitamin E, I.U./lb.	9	9	...	4	...	4	6
Riboflavin, mg./lb.	3	1.5	1.8	1.2	1.9	0.2	3
Vitamin B_{12}, mcg./lb.	4	3	4	1.5	3	3	6
Niacin, mg./lb.	25	20	25	15	20	15	20
Pantothenic acid, mg./lb.	6	6	6	3	4	6	8
Choline, mg./lb.	600	600	800	450	800	450	600
Turkeys							
Calcium, per cent	2	2	2	...	...	2*	3*
Phosphorus, per cent	1	1	1	...	...	0.75–0.8	1.5
Manganese, mg./lb.	30	30	50	...	...	25	50
Salt, added per cent	0.4–0.5	0.4–0.5	1	...	...	0.25–0.5	1
Iodine, mg./lb.	0.5	0.5	1	...	...	0.5	1
Vitamin A, U.S.P./lb.	5000	5000	8000	...	...	5000	10,000
Vitamin D, I.C./lb.	600	600	1200	...	...	600	1200
Vitamin E, I.U./lb.	4	4	...	...	...	4	6
Riboflavin, mg./lb.	3	2	3	...	...	3	5
Vitamin B_{12}, mcg./lb.	5	3	5	...	...	3	4
Niacin, mg./lb.	35	30	40	...		15	30
Pantothenic acid, mg./lb.	8	7	9		...	8	10
Choline, mg./lb.	900	800	1000		...	600	800

[6] Schaible—Margin of safety provided to cover variation in analysis and losses during normal storage.
* Oyster shell or limestone also fed free choice.

wetter droppings. Traces of manganese and iodine should also be added (Table 8–5).

The vitamin needs for growth are extensive (Table 8–5). Vitamin D must be provided in poultry rations for birds kept in confinement more than a few days. Rations containing little or no alfalfa or green grass need a supplement of vitamin A. Rations containing little or no animal protein feeds need riboflavin, pantothenic acid, and vitamin B_{12}. Some rations must also be fortified with vitamin E, choline, niacin, and unidentified factors.

Rations for growth. Any number of chick starting and growing rations may be formulated from the many feeds, minerals, and vitamin supplements on the market. If one knows the nutritive requirements (Table 8–5), allowances for safety (Table 8–6) and composition of feeds (Table 1, Appendix),

Table 8–7

STARTING AND GROWING RATIONS [7]

	Growing Farm Replacement Stock			Broilers	
	Starter	Grower	Grower Restricted	Starter 0–5 wks.	Finisher 6–10 wks.
Ground wheat [8]	600 lbs.	560 lbs.	600 lbs.	540 lbs.	620 lbs.
Ground yellow corn	370	300	600	550	675
Ground barley [8]	200	400	260	...	...
Pulverized oats [8]	100	380	100	...	...
Tallow or grease, stabilized	30		...	80	80
Dehydrated green feed	60	60	75	40	40
Meat meal, 50% protein	50	50	50	...	...
Fish meal, 65% protein	40	20	20	...	...
Dried whey	20	20	20	...	...
Distillers' dried solubles, corn	20	20	20	...	...
Soybean oil meal, 50% protein	460	140	200	715	510
Ground limestone	25	30	30	40	40
Dicalcium phosphate	15	10	15	25	25
Iodized salt	8	10	8	6	6
Vitamin A stabilized 10,000 I.U./gm.	0.25	0.25	0.25	0.25	0.25
Vitamin D, 1500 I.C.U./gm.	0.5	0.5	0.5	1	1
Butylated hydroxy toluene	0.25	0.25	0.25	0.25	0.25
Manganese sulfate, feed grade	0.25	0.25	0.3	0.4	0.4
De methionine, feed grade	.		.	0.5	0.5
Choline chloride, 25%	.			2	2
Vitamin B_{12}, 6 mg./lb.	1	1	1	2	2.5
Coccidiostat (su p.)	+	+	+	+	+
Riboflavin	2 gram	2 gram	2 gram	4 gram	2 gram
Calcium pantothenate	1		1	3	2
Niacin				15	15
Antibiotic	4–10	4–10	4–10	4–10	4–10
Arsenic acid derivative	45–90			45–90	45–90
Menadione sodium bisulfite	1		1	1	1
Crude protein, %	21	15.5	16	24.0	19.9
Crude fat, %	4.1	3	2.9	6.1	6.4
Crude fiber, %	4.4	5.4	4.2	2.8	2.7
Productive energy, Cal./lb.	957	945	968	1004	1036
Calorie/Protein ratio	45.6	61	60.5	41.9	52.2
Metabolizable energy, Cal./lb.	1353	1364	1398	1425	1472
Calorie/Protein ratio	64.4	88	87.4	59.5	74.1
Calcium, %	1.2	1.14	1.21	1.21	1.18
Inorganic phosphorus, %	.44	.35	.40	0.36	0.35
Manganese, mg./lb.	25	25.8	27.2	37	35.2
Vitamin A, I.U./lb.	3091	3042	3830	2681	2813
Vitamin D, I.C.U./lb.	170	170	170	340	340
Riboflavin, mg./lb.	2.2	2	2.2	3.2	2
Pantothenic acid, mg./lb.	5.7	5.4	5.5	6.3	5.7
Choline, mg./lb.	594	479	471	639	545
Vitamin B_{12}, mcg./lb.	5.5	4.6	4.6	6	7.5
Niacin, mg./lb.	19.2	18.8	18.4	25.1	24.8

[7] Ontario Agricultural College Poultry Feed Formulas for 1958.
[8] Corn may replace these grains.

Table 8–8

AVERAGE GROWTH AND FEED CONSUMPTION (AVERAGE OF BOTH SEXES IN POUNDS, EXCEPT WHERE NOTED) **

Age Weeks	Heavy Breeds of Chickens		Leghorns		Bronze Turkeys		Beltsville Tur.		Pekin Ducks	
	Weight	Feed	Weight	Feed	Weight	Feed	Weight	Feed	Weight	Feed
0	.09	...	.09	...	.12	...	.11	...	.12	...
1	.16	.20	.15	.19	.28	.25	.20	.20	.32	.42
2	.32	.58	.30	.55	.55	.60	.40	.50	.77	1.47
3	.54	.97	.49	.90	.90	1.25	.70	1.00	1.59	3.05
4	.79	1.45	.68	1.16	1.40	2.18	1.15	1.80	2.57	5.35
5	1.16	2.10	.90	1.57	2.00	3.38	1.65	2.85	3.42	7.88
6	1.44	3.10	1.20	2.25	2.60	4.68	2.25	4.10	4.00	10.60
7	1.86	4.10	1.49	3.12	3.30	6.38	2.90	5.70	4.74	13.55
8	2.22	5.20	1.75	4.23	4.10	8.78	3.50	7.55	5.44	16.21
9	2.60	6.50	1.95	4.85	4.90	11.15	4.30	9.75	5.80	19.20
10	3.00	8.00	2.15	6.00	5.80	13.90	5.05	12.40	6.51	22.73
11	3.40	9.50	...	...	6.70	16.80	6.05	15.05	6.90	26.33
12	3.80	12.00	1.7 *	7.21 *	7.60	19.80	6.80	17.90	7.50	29.82
16	5.74	21.45	2.4 *	11.68	11.80	35.30	9.25	31.50	...	...
20	6.55	30.76	3.0 *	16.14 *	15.50	52.70	...	...	...	...
24	...	...	3.4 *	21.07 *	19.10	73.00	...	...	...	...
28	...	...	...	...	21.33	92.75	...	...	...	...

** Schaible.
* Pullets only.

it is rather easy but time consuming to formulate a poultry ration. Rations should be test fed to poultry for palatability, ease of feeding, and results (biological analysis.

Table 8–7 lists five ration formulas for growing chickens. The starter ration for farm replacement chicks is lower in protein (21 per cent) than the broiler starter (24 per cent protein), because early, rapid growth is desired in broilers but is not necessary for pullets to be raised for egg production.

Feeding should be started as soon as the chicks are placed in the brooding pen. The feeders should be filled and placed near the source of heat until the chicks begin to eat well. Then they should be half-filled to reduce wastage and moved farther away from the brooder or source of heat. Feed should be kept before the chicks at all times. Chick trough feeders, about three inches deep, are satisfactory for the first two weeks (Fig. 6–2), and after that, tubular hanging feeders (Fig 7–19) or an automatic feeder (Fig. 6–4) may be used. Chicks should be provided with enough feeding space so that at least half of them can eat at any time. Allow one inch of feeding space per chick the first two weeks, two inches from two to four weeks, three inches from five to eight weeks, and four inches thereafter.

The feed consumption will vary widely with the breed of chickens, growth rate, protein and calorie content of the ration, and other factors. The growth rate, feed consumption, and feed efficiency that may be expected for different species of poultry is given in Table 8–8. The growth rate and feed consumption of a special cross or broiler production is given on Table 8–9.

Table 8–9

GROWTH RATE AND FEED CONSUMPTION OF VANTRESS X WHITE PLYMOUTH ROCK BROILERS (AVERAGE OF BOTH SEXES) *

Age in Weeks	Av. Wt. Lbs.	Lbs. Feed Per Lb. of Gain to Date	Cumulative Feed (Lbs.) per Bird
1	0.30	0.75	0.23
2	0.58	0.95	0.55
3	0.90	1.30	1.17
4	1.33	1.62	2.15
5	1.66	1.85	3.07
6	2.10	1.95	4.10
7	2.59	2.05	5.31
8	3.05	2.20	6.71
9	3.53	2.32	8.19
10	4.03	2.42	9.75

* Ontario Poultry Feed Formulas, p. 34.

At eight weeks of age, females weigh approximately 87.5 per cent as much as males and have a feed efficiency about 95 per cent as good as the males. At ten weeks of age, females weigh approximately 80 per cent as much as males and have a feed efficiency about 90 per cent as good as the males.

Watering. An ample supply of clean water should be kept available at all times. Each 100 chickens should be provided with two 1-gallon fountains (Table 8–10 and Fig. 6–2) the first two or three weeks and 40 inches of drinking space or two 3-gallon fountains the remainder of the brooding period.

Lights. A small light is desirable at all times in the brooder house. A 7 to 10 watt bulb under the hover and a 15 to 20 watt bulb for each 200 square feet of floor space is desirable.

Finishing broilers. A ration of lower protein and higher calorie content than that used for starting broilers is economical for finishing them (Table 8–7). This ration may be fed from about the sixth week until the birds are marketed. Another way of reducing the protein and increasing the energy is to feed whole corn free choice with the starting mash from about the sixth week until the broilers are marketed. Reducing the protein will not result in greater gains but does improve the finish of the birds and reduces the cost of the ration.

Use of hormones. Diethylstilbesterol pellets may be implanted under the neck skin (Fig. 6–16 and p. 233) or dienestrol diacetate may be incorporated in the feed at a level of 30 milligrams per pound about two to four weeks before the birds are marketed in order to produce a better (fat) finish on growing chickens and turkeys.

Finishing pullets for layers. Chickens to be reared for egg production are generally started on a ration containing 20 to 21 per cent protein (Table 8–7). When the birds are about eight or nine weeks old, the protein content is reduced to 17 or 18 per cent or even as low as 15 or 16 per cent (Table 8–4), the level recommended for egg production.

Table 8–10

FEED AND WATER CONSUMPTION AND EATING AND DRINKING SPACE FOR POULTRY *

Kind of poultry	Age in Weeks	Feed Consumption: Lbs. Feed Per Day	Feed Consumption: Eating Space Feet **	Water Consumption: Gallons Per Day	Water Consumption: Drinking Space Feet
Chickens, per 100 birds	0–2		8	1	2
	3–4	up to 5.5	10	1.5	2
	5–6	7 to 9	15	2	3
	7–8	10 to 13	20	2.5	3
	9–12	13 to 17	25	3	4
	13–16		30	4	4
	17–20	14 to 23	35	4.5	5
	Mature	16 to 35	40	5	5
Turkeys, per 100 birds	0–2	up to 4	16	1	3
	3–4	4 to 13	24	2	6
	5–6	15 to 19	32	4	7
	7–8	23 to 35	40	6	8
	9–16	38 to 43	45	10	12
	17 to maturity	up to 75	50–60	20	12

* Range covers light to heavy breed chickens and 0 to 80 per cent production and Beltsville White to Broad Breasted Bronze turkeys and 0 to 70 per cent production.
** A minimum of 6 hanging tubular feeders per 100 birds may be used from about the second week on.

Restricted feeding from about nine to ten weeks of age until the birds are at about 10 per cent production (about 20 weeks) reduces feed cost during the period and may, under certain conditions, result in economical egg production during the first year. More data are needed on this practice. Restricted nutrient intake may be accomplished by feeding a bulky (high fiber) feed or by actually withholding feed from the birds a part of each day. The former may be handled with greater ease, saving labor and lessening the danger of birds developing faults.

Restricted feeding delays sexual maturity about two weeks, but if delayed too long, will increase broodiness of the flock. However, feed restricted birds come into production at a more rapid rate when the restriction is removed, and their eggs reach normal size in a shorter period of time. This might be desired if hatching eggs are wanted.

Feeding breeding cockerels. The cockerels should be separated from the pullets when four to eight weeks old. If the cockerels are to be sold for meat, they may be fed and managed the same as broiler chicks. If they are to be kept for breeding purposes, they may be fed a growing mash and grain free choice. The nearer they reach maturity, the more grain and the less mash they will consume.

Feeding roasters. Chickens to be raised and sold as roasters, about four to seven pounds live weight, may be fed a growing mash and grain free choice after they are six to eight weeks old. They are generally marketed when 3.5 to 5 months old The larger they become, the greater the per cent of grain and the less the per cent of mash consumed. Since they are kept beyond the age

of most rapid growth, more pounds of feed are required to produce a pound of roaster than to produce a pound of broiler or fryer.

Feeding capons. Birds marketed as capons are usually five to seven months old. Since they are kept beyond the period of rapid growth, they may be fed free choice of a growing mash and whole grains. The pounds of feed required to produce a pound of capon is greater than for the production of a pound of broiler, fryer, small roaster, duck, or turkey. However, if the birds are grown on good grass range and fed a ration consisting largely of grains, the feed cost of capon production is not great.

Feeding for Egg Production

Feeding for egg production involves feeding for numbers of eggs, egg quality, hatchability, and control of molt and broodiness. The same type of ration may be used for all of the above purposes. However, the system of management is varied somewhat. It requires a better ration for the production of hatching eggs than for the production of market eggs. The differences are mainly in vitamin requirements. Since the necessary vitamin supplements are now becoming generally available and cheap, it is advisable to feed a ration that will produce hatchable eggs even though they may be sold as market eggs. The eggs will have greater nutritive value and the layers will have greater vitamin reserves. This will probably result in healthier laying flocks.

The nutritive requirements for egg production. The nutritive needs for egg production include those for maintenance, growth of pullet layers, and the nutrients in the eggs produced. The nutritive requirements will be greater for birds with an inherited capacity for high egg production than for birds that will lay only a few eggs. The standard-weight egg contains about 95 calories of gross energy, 7.5 grams of crude protein, and 2 grams of calcium.

The *energy needs* of a four- to five-and-one-half-pound hen include .145 to .227 pounds of feed daily for maintenance, and .078 to .1 pound for the production of an egg, or a total of .223 to .327 pounds. Naturally, the larger the bird and the larger the egg, the greater the energy needs for egg production.

The *protein needs* for egg production include about 6.5 grams daily for maintenance, and 7.5 grams for the egg. An additional amount is needed the first few months of production to meet the growth requirements. A protein content of 16 per cent (Table 8–4) in most laying rations will generally take care of the protein requirements. Pullets may need as high as 18 per cent protein the first few months of production to take care of the intensity of egg production and body growth. Old hens, on the other hand, may produce as well on 13 to 15 per cent protein as on higher levels.

Molting birds need proteins of high cystine content for renewal of feathers Tests conducted at the Nebraska Agricultural Experiment Station have shown that the daily endogenous nitrogen loss among nonmolting hens amounts to about 144 milligrams per kilogram of body weight, and among

Table 8–11

SUGGESTED LAYING MASH AND CONCENTRATES *

Ingredients	Allmash Laying Mash	Concentrates to be Fed With		
		1 **	2 ***	3 ****
Ground yellow corn, lbs.	1178.5	467	1016	167
Oats, heavy, pulverized, lbs.	100	200	..	..
Middlings, standard, lbs.	200	400	..	100
Fat, stabilized, animal, lbs.	20	20	..	20
Alfalfa meal, dehydrated, 17%, lbs.	50	100	100	200
Soybean meal, solvent, lbs.	240	540	700	970
Meat and bone scrap, 50% protein, lbs.	100	200	100	400
Salt, iodized, lbs.	10	20	20	40
Trace mineral mix, 30 mg. manganese/lb. lbs.	1	2	2	4
Limestone, ground, lbs. †	75	..	..	..
Dicalcium phosphate, lbs.	25	50	60	93
Choline chloride, 25%, lbs.	0.5	1	2	6
Antibiotics	+	+	+	+
Antioxidant	+	+	+	+
Added vitamins	..	..	..	..
Riboflavin, grams	1.5	3	3	5
Niacin, grams	5.0	10	20	50
Vitamin A, million units	2	4	4	7.5
Vitamin D, million units	1	2	2	4.0
Calculated analysis				
Crude protein, %	15.7	25.11	23.86	34.04
Calcium, %	2.25	1.82	1.39	3.93
Phosphorous, total%	.78	1.31	1.1	1.79
available, %	.56	1.01	.9	1.51
Riboflavin, mg/lb.	1.61	2.77	2.7	4.36
Niacin, mg./lb.	16.82	24.13	22.26	40.49
Pantothentic acid, mg/lb.	3.67	5.56	4.1	4.15
Choline, mg/lb.	462	765	763	1195
Vitamin D, I.C.U./lb.	500	1000	1000	2000
Vitamin A, I.U./lb.	4370	7300	7750	13,875
Productive energy, cal./lb.	913	720	837	607
Calorie/Protein ratio	58	.	..	..

* Creek and Combs.
** Ration to be fed as 1 part concentrate to 1 part corn.
*** Ration to be fed as 2 parts concentrate to 1 part corn and 1 part wheat.
**** Ration to be fed as 1 part concentrate to 3 parts of grain mixture containing 50% corn, 20% oats, 20% barley.
† Oyster shell or limestone grit to be kept before the layers.
+ Used according to manufacturer's recommendations.

molting hens, 219 milligrams. Evidently the molting hen breaks down tissue protein to supply the amino acid cystine for feather growth. When 145 milligrams of cystine were added to the diet of the molting hen, the endogenous nitrogen loss was reduced to 137 milligrams. The feeding of cystine exerted a protein sparing out of proportion to its nitrogen content, thus indicating its value for feather growth.

The *mineral needs* for egg production are mostly needs for calcium and phosphorus (Table 8–6). The shell of the egg constitutes about 11 per cent of its total weight. It consists largely of calcium carbonate. The yolk of the egg contains about 80 milligrams of phosphorus. The laying ration should

contain about 2.3 per cent calcium and .8 per cent phosphorus. The requirements will vary within wide limits, depending on the rate of production. Oyster shells or some other source of calcium should be kept available to supply additional calcium for high-producing hens. These hens will eat more mash feed, and therefore will secure additional phosphorus from this source.

The egg contains 1.5 milligrams of iron. Studies made at Ohio State University and elsewhere have shown that the traces of iron found in poultry feeds meet the iron requirements for egg production. The traces of iodine found in oyster shell, fish meal, and other marine products meet the iodine needs of laying and breeding stock.

The salt needs are met by the use of animal protein feeds. When vegetable protein feeds are used, it is advisable to add 0.5 per cent sodium chloride to the ration. It may also be added to rations containing animal protein feeds.

The laying and breeding ration should contain fifty parts of manganese per million for the production of normal shell texture and hatchability.

The *vitamin needs* for egg production should include about 3,150 International units of vitamin A, 400 I.C.V. of vitamin D, and 1.2 milligrams of riboflavin (G) per pound of feed (Tables 8–5 and 6).

A hundred layers will eat from 20 to 32 pounds of feed per day depending on their size and rate of production. If 67 per cent of it is corn, they should be fed 13 to 21 pounds daily. This would be about 1.5 to 2.5 gallons per 100 birds daily. It is doubtful if the manager can estimate accurately the amount of grain to be fed daily with this system of feeding.

Feeding layers. Feed should be kept before the birds at all times, since it adds to the labor and guesswork in feeding to attempt to restrict the feeding to a certain number of hours each day. There is a tendency for heavy birds to become too fat when grain and/or high energy mash is kept before them all the time (Table 8–12).

Mash feed for feeding with a limited amount of whole grain may be prepared from a concentrate as above, or compounded specifically for this purpose. A mash feed designated for feeding with a limited amount of grain generally contains about 20 per cent protein. To determine the proportion of mash and grain to feed for a 16 per cent protein intake, the following procedure may be used as a substitute for the algebraic expression below:

CORN 9% PROTEIN	16 PARTS CORN
CONCENTRATE 32% PROTEIN	7 PARTS CORN

Total the parts of corn and concentrate, (16 + 7 or 23).

Divide the parts of each by the total and multiply the result by 100 to obtain the per cent of each to be used.

$7 \div 23 = .3043 \times 100 = 30.43\%$ concentrate

$16 \div 23 = .6978 \times 100 = 69.78\%$ corn

Table 8–12

INFLUENCE OF ENERGY LEVEL AND RESTRICTED FEEDING ON HEAVY BREED EGG PRODUCTION *

Observation	Ad Libitum		Controlled **	
	Low Energy	High Energy	Low Energy	High Energy
Egg production, %, 40 weeks	57	53	41	57
Final body wt, lbs.	7.16	8.19	6.30	7.57
Mortality, %	7	24	8	4
Eggs per bird, hen day basis	159	154	115	159
Eggs per bird, hen housed basis	154	138	110	155
Total eggs produced	11,586	10,371	8,272	11,625
Feed per bird, lbs.	100.7	89.9	82.2	78.5
Feed per dozen eggs, lbs.	7.58	6.99	8.56	5.92
Egg weight, 9 mo., grams	67.8	67.3	62.9	67.2
Productive energy of ration, Cal./lb.	857	1014	857	

* Singsen, et al
** Fed according to calculated energy needs. High energy rations fed-85% of the low energy ration consumed.

Laying rations. The composition of laying rations will vary with market or hatching egg production. It will also vary with the method of feeding, (p. 259)—for instance, all-mash, mash and limited grain, or mash concentrate and grain free choice.

Table 8–11 gives the formulas for an all-mash ration for layers in floor pens. It also lists the formula of mash concentrates which may be used for making mashes of lower protein content. These are typical of the many satisfactory formulas that may be developed. Nearly all agricultural colleges and experiment stations have formulas for all kinds of poultry rations suitable and economical for use in their sections of the country.

Mash feeds from mash concentrates may be made by diluting the concentrates with cereal grain to produce a mash of a desired lower protein content. For example, to prepare a 16 per cent protein all-mash from a 32 per cent protein concentrate and corn (9 per cent protein):

Let x = Number of pounds of corn required per ton.

Then 2000 − x = the number of pounds of concentrate required per ton.

$$9x + 32(2000 - x) = 16 \text{ times } 2000$$
$$9x + 64{,}000 - 32x = 32{,}000$$
$$-23x = -32{,}000$$
$$x = 1391.3 \text{ lbs. corn}$$
$$2000 - x = 608.7 \text{ lbs. concentrate}$$

Satisfactory egg production may be obtained, with light breeds, by feeding a 24 to 32 per cent protein mash concentrate and grains free choice. Heavy breeds eat too much grain with this system of feeding and become too fat (Table 8–12). The higher the protein content of the concentrate, the less consumed the greater the amount of corn that will be eaten. Mash concentrates should be mixed with grains according to the directions of the manufacturers.

Feeding for control of molt. Birds do not molt and lay well at the same time. Early-hatched pullets generally lay well for a period of two or three months. Then they show a neck molt which may become general unless precautions are taken to check it. The practice used on some farms is to use artificial lights at night. This will check the molt and hold up production for about a month or six weeks. Then when production starts down again, pullets are fed once or twice daily.

The molting of laying hens in the fall of the year, when egg prices are the highest, is another problem faced by poultrymen. To avoid a molt or to hasten birds through it, the consumption of mash feed should be encouraged. The use of lights and wet mash will also be beneficial. Feathers are largely protein, and mash feed contains the nutrients for feather growth. Some poultrymen prefer feeding pelleted mash in place of wet mash in order to stimulate feed consumption.

Some poultrymen force the hens to molt in the early summer when egg prices are low. The idea is to have the birds over the molt and back in production in late summer or early fall when egg prices are high. The mash feed is taken away and the birds are given water and grains for several days. The birds go out of production, but it is difficult to get all of them to go through a complete molt. The results obtained have been variable in different parts of the country. The forced molting of birds is a questionable practice. A better program is to feed the birds to produce all the eggs they will produce all the time.

Feeding for fall and winter egg production. Toward the end of the first laying year or late in the summer or early fall many hens go out of production. Such birds may be kept in production until late fall or early winter by the use of artificial lights, and the feeding of pellets. Slow-maturing pullets may be brought into production by the same practice. It also may be desirable to restrict the grain feeding in order to secure sufficient mash consumption for satisfactory egg production.

It should be remembered that hens which lay well in the fall will not lay so well in the spring. Flock owners who expect a high rate of production for hatching eggs in the late winter and spring should not force the flocks for high production in the fall.

Feeding for egg quality. The rations fed to laying hens influence both the market grade of eggs produced and their nutritive value.

Egg size is not influenced much by the ration. A good supply of oyster shells or limestone grit and vitamin D results in thicker eggshells and consequently slightly heavier eggs. Age and size of bird, rate and time of production, and breeding are the chief factors influencing egg size.

Shell quality is influenced by the calcium and manganese content of the ration and by the amount of the vitamin D factor supplied. Good quality oyster shells or limestone grit, or both, should be readily available for layers at all times. A special compartment at one or both ends of the feed hopper should be reserved for the shell or limestone. In case the eggshells become thin and crack easily, mineral consumption may be increased by sprinkling a handful of oyster shells over the mash feed in the hopper every day or so.

An ample supply of vitamin D should be provided by allowing the birds on range or by the use of feeding oil or a dry form of vitamin D when they are confined.

The *albumen quality* of eggs is influenced by the amount of succulent feed, such as cabbage, green grass, and lettuce that is fed. Birds should not be given more than about four pounds of succulent feed per hundred hens per day. If birds eat certain kinds of weeds, the albumen of the eggs produced may have a green or pink color, especially after being held in storage. Feeding cottonseed meal may also produce egg whites with a pinkish color. Rations high in protein produce a tougher white, which has a greater tendency to stick to the shell.

Yolk color is due to the amount of a carotinoid pigment, xanthophyll, fed in the ration. It is found in yellow corn, green grass, and alfalfa meal. Birds given green grass range and fed an abundance of yellow corn will produce eggs with dark yellow yolks. Eggs with pale yolks may be produced by keeping birds in confinement and feeding not more than 30 per cent yellow corn and 5 per cent alfalfa meal in the ration.

The use of more than 5 per cent cottonseed meal in the ration results in eggs with mottled yellow, salmon green, and nearly black yolks after they have been held in storage for a month or longer. A trace of nicarbazin (p. 313) will also cause mottling of yolks.

Weeds of the mustard family, such as shepherd's-purse and penny cress, impart a very undesirable olive color to the egg yolks of hens which pasture on them.

Keeping birds in confinement and feeding an all-mash ration results in the production of eggs with more uniform yolk color than when birds are given grass range or fed a grain and mash ration.

The *vitamin content* of the egg is influenced greatly by the ration fed. The more vitamins A, D, and riboflavin fed in the ration, the greater will be the content of these vitamins in the egg. The average run of eggs contains about 20 International units of vitamin A per gram of yolk (300 units per egg). The potency may be doubled when birds are fed rations high in vitamin A. When the vitamin A content of the ration is low, the vitamin A content may drop to 5 or 6 units per gram.

The average egg contains 10 to 12 U.S.P. units of vitamin D per yolk. When rations high in vitamin D are fed, the vitamin D content of the egg is increased to 60 to 80 units.

Both the white and yolk of the egg contain riboflavin. The average egg contains about .27 milligram or 270 gammas of riboflavin. The amount may be increased greatly by increasing the riboflavin content of the ration. The vitamin B_{12} content is also influenced by the ration fed.

Feeding for hatchability. It requires a better ration for the production of hatching eggs than for the production of market eggs. The hen must store all the nutrients in the egg that are needed for the development of the embryo. Since much mineral material needs to be assimilated in the embryo, the vitamin D content of the egg must be high for hatchability. The riboflavin

Table 8–13

RELATION OF EGG PRODUCTION, RATE OF FEED CONSUMPTION AND FEED EFFICIENCY IN BIRDS OF DIFFERENT WEIGHT *

Rate of Egg Production	Weight of Birds (Lbs.)							
	4		5		6		7	
	Daily Per 100 Hens	Per Doz Eggs	Daily Per 100 Hens	Per Doz. Eggs	Daily Per 100 Hens	Per Doz. Eggs	Daily Per 100 Hens	Per Doz. Eggs
%	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
0	16		18		20		22	
10	17	20.3	19	23.2	22	25.9	24	28.4
20	18	11.0	21	12.4	23	13.8	25	15.1
30	20	7.9	22	8.9	25	9.8	27	10.6
40	21	6.4	24	7.1	26	7.8	28	8.4
50	23	5.4	25	6.0	27	6.6	29	7.1
60	24	4.8	26	5.3	29	5.7	31	6.2
70	25	4.4	28	4.8	30	5.2	32	5.5
80	27	4.0	29	4.4	32	4.7	34	5.0
90	28	3.8	31	4.1	33	4.4	35	4.7

* Ontario Poultry Feed Formulas, 1958 p. 26.

and B_{12} content of the egg must also be high in order to meet the growth requirements of the embryo.

Special care in feeding is necessary when the breeding flock is kept in confinement. The birds should be fed fish oil or other sources of vitamin D to take the place of sunlight, and high-quality alfalfa or other legume hay to take the place of green grass. The breeding ration should also contain natural feedstuffs rich in B-complex vitamins such as liver meal, fish solubles, fish meal, milk, whey, brewers' yeast or distillers' solubles. Pure riboflavin, vitamin B_{12}, niacin, pantothenic acid or concentrates rich in these factors are now being used to replace most of the above feeds.

Most poultrymen believe that it pays to feed for the production of hatching eggs even though they are to be sold for market. The eggs will be of higher nutritive value. The birds will have higher vitamin reserves and better health.

Feed consumption of laying hens will vary with the size of birds, rate of production, kind of ration, weather conditions, and housing (cages or floor). The following formula maybe used as an aid in estimating the feed consumption. Daily feed consumption of 100 hens = 8.3 + 2.2 (avg. wt. of birds) + 0.1 (per cent egg production).

Table 8–13 gives the estimated daily feed consumption of layers of different weight and egg production. Over 50 per cent of the feed eaten is for required nourishment. Small breeds eat considerably less feed than heavy breeds to produce the same number and weight of eggs, because they require less feed for nourishment.

Breeder male feed consumption is about the same as that of meat-type hens. They need less mash feed and calcium and more grains than the laying hens.

Fattening Poultry

Poultry is fattened to improve the quality of the meat and to increase the weight. Birds that are mature, or nearly so, may be fattened more easily than growing stock. The rations fed and the length of the finishing or fattening period influence the gains and the quality of the product produced.

The fattening or finishing period is short, varying from about one week in the case of hens to about two weeks for fryers.

The birds should be confined to pens or fattening batteries. Birds that are unusually active, easily frightened, or restless do not gain well.

Since the feeding period is short, no special provision need be made for vitamins A and D in the ration. Fish oils and alfalfa that are usually fed to supply these vitamins may be replaced by corn in the fattening ration.

The feed should consist mainly of ground grains. All of the ration and liquid consumed is given in the form of a wet mash. The birds eat more of the mash than they otherwise would, in order to satisfy their needs for water.

The mash is generally mixed with milk to make a batter that pours easily. Milk adds to palatability of the fattening ration and results in better gains.

The fattening mash and milk or water are generally mixed in the proportion of forty parts by weight of mash and sixty parts of liquid to make a mash of the proper consistency for pouring.

Feeding practice. It is customary to fatten or finish fryers, roasters, capons, and old hens, unless they are already in good flesh.

The birds are generally confined to pens, coops, or batteries. Very little feed is given the first day of confinement in order to develop a keen appetite. The birds are given about as much feed as they will clean up in about five minutes in the morning of the second day, and as much as they will clean up in ten minutes in the evening. On the third day, the birds may be fed as much as they will clean up morning, noon, and night in fifteen- to thirty-minute feeding periods.

In large fattening stations, birds are fed by what is sometimes termed the "continuous pouring" method. They are given as much feed as they will clean up in a few minutes several times a day.

Hens are generally fattened for about a week if in poor flesh, but not at all if in good condition. The gains are usually small, generally not more than about 7 per cent However, the quality of the meat is improved.

Roasters, including capons, are generally fattened about ten days Gains of 5 to 15 per cent may be expected.

Fryers, including large broilers, may be fattened for about two weeks, or as long as rapid gains and good feed consumption are maintained. Gains of 10 to 30 per cent may be expected.

Quality of poultry meat. The fattening ration influences the skin color, tenderness of the meat, flavor, firmness of the fat, and vitamin content of the edible tissues.

Skin color, in yellow-skinned varieties, is influenced by the fattening ration. White corn and milk in the fattening ration results in birds with

pale skin color. Birds fattened on range and fed an abundance of yellow corn have a rich yellow skin color.

Tenderness of meat is influenced some by the ration fed as well as by age and the method of cooking. Rapidly growing and well-fattened birds are more tender than slow-growing and poorly fattened ones. Range-fattened birds are tougher than those fattened in pens or batteries.

Flavor of poultry meat is influenced by the ration fed. The use of oily fish meal or fish oil in the fattening or finishing ration should be discontinued at least two weeks before the birds are marketed. Otherwise, the cooked meat may have a fishy odor and taste.

Birds fattened largely on corn have a meat that is more palatable and juicy than birds fattened largely on wheat.

Fat may be increased in the muscles and elsewhere by administration of estrogen just before and during the fattening period. Mutton fat added to the ration produces a firm fat while vegetable oils produce a soft fat.

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Chapter 9

Poultry Diseases

DISEASE MAY BE DEFINED as any deviation from the normal state of health, whether it be a slight ailment or one endangering life. Poultry diseases and their control are costly from the standpoint of actual losses because of the cost of drugs, vaccines and disinfectants and labor involved in their use for prevention and treatment of poultry ailments (Table 9–1).

Table 9–1

MORTALITY IN RANDOM SAMPLE AND EGG LAYING TESTS *

KIND OF POULTRY	NUMBER OF ENTRIES	MORTALITY PER CENT	
		Average	Range
Chicken laying flocks			
Egg laying contests	5 contests	9.15	5.24 to 11.91
Egg laying contests	11 breeds	9.15	3.85 to 15.38
12th Georgia broiler-breeder test	25 entries	8.10	0.00 to 32.50
Random sample egg laying	10 contests	10.40	5.00 to 20.00
Meat performance tests	15 entries	8.00	5.00 to 13.00
Chicken broilers			
10th California test (9 wks.)	17 entries	2.5	0.0 to 5.0
12th Maine test	20 entries	1.6	0.0 to 6.3
6th Michigan test	6 entries	3.4	0.9 to 5.5
Arkansas tests (8 wks.)	13 entries	2.5	0.8 to 3.2
Turkeys			
4th Massachusetts test (24 wks.)	20 entries	4.8	0.0 to 15.4
Minnesota test (25 wks.)	20 entries	8.8	7.7 to 9.7
Pennsylvania test (26 wks.)	30 entries	11.9	2.1 to 25.9
5th Texas test (26 wks.)	23 entries	7.9	4.0 to 16.0

* Council of American Official Poultry Tests. 1957–1958. Report 20.

In the losses from disease, one must consider not only mortality but losses from poor hatchability, growth, and production; poorly finished market birds; and overhead expense of partly filled houses and idle equipment which result from mortality and removal of sick birds.

Disease

Terminology. A knowledge of common disease terms is needed in studying poultry diseases. A few of the most widely used terms are listed here.

Fig. 9–1. Some disease-producing microorganisms, magnified several hundred times. Top left, cocci or round bacteria, found in pus and skin lesions; center, bacilli or rod-shaped bacteria, cause pullorum disease; right, aspergillus or mold, causes aspergillosis or brooder pneumonia. Bottom: left, spirilla or curved bacteria found in some blood diseases; center, monilia or mold, causes thrush; right, protozoa, coccidia—the cause of coccidiosis.

Infection is the invasion of the tissues of the body by pathogenic organisms in such a way as to favor their growth and permit their toxins to injure the tissues.

Pathogenic refers to the ability of an organism to cause disease.

Immunity is the power of resistance of an animal to resist and overcome infection.

Etiology is the study of the cause of a disease.

Inflammation is the reaction of body tissues to irritation. It is characterized by swelling, heat, redness, and pain. The ending, "itis" is often used to indicate inflammation of a part; for example, enteritis means inflammation of the intestines.

A *lesion* is any hurt, wound, or local degeneration of tissue.

A *vaccine* is a suspension of living disease-producing organisms (bacteria or viruses).

A *bacterin* is a suspension of dead disease-producing organisms.

A *toxin* is a poisonous substance produced by bacterial action.

Causes. Diseases may be produced by living organisms such as parasites, protozoa, fungi, bacteria, and viruses (Fig. 9–1).

Parasites are here regarded as small multicellular animal organisms. Examples are lice and roundworms.

Protozoa are microscopic one-celled animals. Examples are the causative organisms of coccidiosis and blackhead.

Molds or fungi are low forms of plants. A few of the many forms which appear in nature produce diseases. Examples of poultry diseases produced by them are aspergillosis and favus.

Bacteria are microscopic one-celled plants. They are widely distributed in nature, but only a few of them produce disease. Examples of bacterial poultry diseases are pullorum and tuberculosis.

Viruses are organisms so small that they cannot be seen even with the microscope. The proof of their existence is their ability to reproduce disease by introducing substances containing them into the body of a susceptible animal. Fowl pox and laryngotracheitis are examples of poultry virus diseases.

The disease-producing organisms may gain entrance to the body by way of the mouth, nose, eye, skin, cloaca, or egg. They produce disease by irritation, inflammation, use of body nourishment, mechanical obstruction of organs, destruction of tissue, or production of toxins.

Disease may also be produced by body deformities, injury, faulty nutrition, poisons, and poor environment. This group of diseases is not transmissible from one bird to another.

Infections. The ability of disease-producing organisms to produce disease depends upon a number of factors.

Virulence of organisms is a determining factor in the production and severity of an infectious disease. The longer infective agents are away from the body and the more they are exposed to adverse environmental conditions, such as high and low temperatures, dryness, air, sunlight, or disinfectants, the less the chances that they will produce disease.

The *number of organisms* gaining entrance to the body influences disease production and its course. Small numbers of disease-producing organisms may be thrown off by the body, but massive doses cannot be combated by the natural body defenses.

Resistance of birds or their immunity against infection influences disease production. Immunity may be inherited or it may be acquired. It may be acquired by having had the disease or by the intake of a few organisms from time to time which stimulated the production of immune substances.

Well-fed birds have greater natural resistance against infection than improperly fed individuals.

Overcrowding, drafts, extremes of temperature, and forced production lower resistance against infection.

Spread of disease. The parasites, fungi, protozoa, bacteria, and viruses may escape from the body of diseased birds by way of the droppings, mouth, wounds, or by blood obtained by blood-sucking insects. After leaving the body of the bird, the disease-producing agents may be passed on to susceptible birds in a number of ways.

Litter and soil contaminated by droppings from diseased birds are probably the most common means of spreading disease. It seems to be the nature of birds to pick up material from the litter and soil. In so doing, they are likely to become infected, if many disease-producing organisms are present.

Feed and water contaminated by droppings or discharges from the mouth

of infected birds serve as a common means of spreading disease. Feeding chickens on the ground or litter and permitting them to drink from dirty vessels or water puddles increase the chances of spreading disease.

Close contact may be a means of spreading external parasites and respiratory diseases. Healthy birds may inhale germs from diseased birds which are coughing, sneezing, or gasping for breath. Lice may crawl from one bird to another.

Animal carriers spread disease. These include fowls, wild birds, insects, and vermin. Some fowls may harbor disease-producing organisms, e.g., coccidiosis, and yet show no external symptoms of disease. Wild birds are affected by some of the diseases that affect poultry. They may fly from one farm to another, carrying disease germs with them. Flies, mosquitoes, earthworms, snails, bugs, and ticks may carry disease organisms and serve as intermediate hosts for the development of some of these organisms. Rats may also serve as a means of spreading disease. Dogs, cats, and other farm animals may carry infective material on their feet.

Movable equipment may be a means of spreading disease. This includes cleaning equipment, coops, feeders and waterers, feed sacks, and egg cases.

The *attendant* or visitors may carry disease-producing organisms on their feet and clothing.

Disease Prevention

The most efficient and economical method of controlling disease lies in the use of preventive measures. The old adage, "an ounce of prevention is worth a pound of cure," certainly applies to poultry diseases. The chicken has small unit value. Medicine and treatment often cost more than the bird is worth. Most diseases have a lasting after-effect on growth or production. Flock preventive measures should be used. These include selection for disease resistance, proper housing, clean range, proper feeding, culling out unhealthy birds, and quarantine of new stock.

Selection of stock. Select healthy fowls for breeders (p. 80). Use pullorum-tested stock (p. 108). Hatch from hens rather than from pullets; this affords more information about the livability of the parents. Use male birds in the breeding pens that come from families having good livability.

Proper housing. Provide adequate floor space (p. 184). This reduces the chances of cannibalism and the spread of disease by close contact and contaminated litter.

Provide adequate ventilation but avoid drafts. Avoid sudden changes in temperature. Drafts and extremes in temperature lower the resistance of birds and make them more susceptible to disease.

Use dropping pits or dropping boards to lessen the chances of spreading disease by droppings.

Use sanitary feeders and waterers. The more fecal material kept out of the feed and water, the less the chances of disease.

Use litter and change it often enough to keep the house reasonably clean and dry. Built-up litter (p. 285) may accomplish the same purpose.

Table 9–2

INFLUENCE OF LITTER ON BROILER GROWTH AND MORTALITY *

Trial	Kind of Litter	Mortality Per cent	Avg. Wt. Pounds	Feed Per Lb. of Gain/Lbs.
1–8 wks.	Compost	5.2	2.47	
	Compost plus antibiotic	4.0	2.54	
	New	5.2	2.44	
	New plus antibiotic	4.0	2.71	
2–10 wks.	Compost	0.0	3.20	2.95
	Compost plus antibiotic	2.5	3.29	2.89
	New	1.7	3.13	2.93
	New plus antibiotic	1.7	3.23	2.85
3–10 wks.	Compost litter			
	All vegetable protein ration	1.25	3.12	
		1.25	3.12	
	Animal protein ration	*1.67*	3.22	
	New litters			
	All vegetable protein ration	1.25	3.00	
		1.25	3.00	
	Animal protein ration	1.67	3.11	

* Kennard et al.

Ranges and yards. The keeping of birds on the same range year after year will result in severe contamination if diseased birds are present in the flock. Some disease germs and parasite eggs will live in the soil for a year or more. Good drainage and aeration of the soil help keep down infection. Keeping the grass cut short or grazed closely provides young, tender vegetation for the birds and at the same time permits greater penetrating power of sunlight. Permanent shade is objectionable—unless there can be good rotation of range with the birds off the ground for two or more years—because it keeps out sunlight and keeps the soil damp. Shady, damp places are favorable for the protection of disease-producing organisms.

The rearing range should be changed each year so that each range has a two- or three-year period during which no birds are kept on it. The same applies to yards attached to permanent houses. Cropping unused ranges and yards assists in keeping them safe for poultry.

If only one small range is available and it becomes contaminated, keep the birds in confinement. Present-day poultry rations, with the birds kept on compost litter, are believed to supply all of the essential nutrients birds obtain when on range.

Sanitation. Sanitation is the establishment of environmental conditions favorable to health. Good houses, equipment, and yards need to be kept clean in order to lessen the chances of disease.

Built-up litter may be a means of controlling diseases according to Kennard and associates of the Ohio Agricultural Experiment Station (Table 9–2). The chicks are started on old (six months or more) used litter rather than on new

litter in clean pens. When the litter becomes caked, it is stirred and a little fresh material added. The thick layer (6–12 inches) of litter keeps the floor warmer and dryer. The alkaline excretory products and/or the micro-organisms living in the litter may reduce the virulence or kill possible pathogens such as viruses, bacteria, and protozoa. The compost litter also has marked B-complex vitamin and protein sparing properties.

The use of compost litter is an entirely opposite approach to sanitation from the following recommendations that have been in use for years.

Cleaning the drinking and feed vessels, perches, nests, floors, and the interior of a house before each new lot of birds is housed aids in disease prevention. Keeping the equipment and pens clean while birds are in them is a further precautionary measure against disease.

Removal of droppings and litter to a distant part of the farm where chickens will not range, and keeping manure storage pits screened against flies, helps prevent the spread of disease. Manure piles serve as breeding places for flies. These insects carry disease and serve as hosts for tapeworm larvae (p. 310).

Disinfection or the killing of any remaining disease-producing organisms will further reduce the possibilities of disease. Chemical disinfectants are not always necessary or practical for this purpose.

Most pathogenic bacteria and viruses soon lose their virulence and die when they are away from the body of the bird. Drying and exposure to air and light aid in their destruction. Thorough cleaning of the house and equipment removes many organisms mechanically and exposes the remaining ones. The action of air and light will generally destroy them, especially if the house is allowed to remain empty for a time.

Chemical disinfectants may be used to hasten the destruction of pathogenic organisms. In most cases the warmer the temperature, the longer the time of action, the stronger the solution of disinfectant, and the smaller the amount of material to be disinfected, the better the effect of the disinfectant. It must be remembered that disinfectants react with feces, litter, dust, feed, and other organic matter and may be "used up" before coming in contact with bacteria. Therefore, cleaning should be thorough before disinfectants are used.

Whitewash, consisting of 1 pound of commercial lye (94 per cent sodium hydroxide) and 2½ pounds of water-slacked lime in 5½ gallons of water, is a cheap, odorless, and efficient disinfectant for general farm use. On prolonged contact, it may be injurious to painted or varnished surfaces, some fabrics, and aluminum. It does not injure metallic and wooden fixtures generally found on the farm

Cresol and other coal tar disinfectants are stable noncorrosive products which may be used on poultry house floors and equipment. A 3 per cent solution is generally used These products should not be used in egg, meat, or other food storage rooms because of the odor transmitted to the foods.

Disinfectants should be used for the purposes intended and according to the directions of the manufacturers. Some are corrosive to metals, some lack stability, and some produce objectionable odors which may be absorbed

by eggs. Disinfectants should be purchased on their strength or the number of gallons of ready-to-use solution that may be made with a given unit of the disinfectant rather than on the price per gallon. Some of the disinfectants used on poultry farms are chlorine compounds, quarternary ammonium compounds, coal tar disinfectants (cresol) and lye.

Feeding. Proper feeding not only protects poultry against nutritional diseases, but results in better vigor and greater resistance against infection by disease-producing organisms. Vitamin A, for instance, stimulates normal secretory power of the epithelial tissue lining the respiratory and digestive tracts and hinders secondary bacterial infections. Adequate supplies of vitamins in the ration afford protection against parasite infestation. A liberal supply of protein in the growing ration increases resistance against coccidiosis and worm infestation.

Removal of unhealthy birds. Whenever unhealthy birds (Table 9–6) are observed in the flock, they should be removed at once. They are often carriers of disease. Unless the bird is a valuable one, it should not be returned to the flock when and if it recovers. Such birds often get out of condition again. It is better to sell them for meat purposes.

Protection against carriers of disease. Do not allow pigeons and wild birds, especially sparrows and starlings, to roost in the houses or feed with the poultry.

Avoid the use of feeds and feeding practices which attract flies or other insects in unusual numbers.

Exterminate rats and mice.

Use new feed sacks for poultry feeds, especially for the growing stock.

Use clean coops for handling birds. Clean and disinfect them before use in another house or on another farm.

Young chicks should be brooded quite a distance from old stock. If the same person must care for both the young and old stock, the shoes should be cleaned and disinfected by stepping in a pan of disinfectant, or rubbers should be put on before going into the brooder house or on the range.

Quarantine of new stock. New stock to be added to the poultry flock, or birds that have been away from the farm at shows, fairs, or other exhibits, should be held in coops or pens away from the flock for about two weeks, to make sure that they do not have any disease or show symptoms of disease infection.

Disease Control

Disease may gain entrance to a flock and outbreaks occur in spite of the use of preventive measures. In case of an outbreak of disease in which the cause and control measures are unknown, a veterinarian should be consulted.

Outbreaks of disease. In case of an outbreak of disease, all sick birds should be removed from the flock and placed in another building. If the disease is general, the flock may be left intact and the entire group treated.

Fresh feed and water should be kept before the birds in clean containers.

Table 9-3

PRINCIPAL DISEASES OF GROWING CHICKENS AND THE PERCENTAGE DISTRIBUTION AMONG THE AUTOPSIES *

Disease	Age of Birds		
	1-4 Weeks	5-12 Weeks	13-24 Weeks
Pullorum	27.9	0.7	0.6
Coccidiosis	20.5	49.7	24.5
Ulceration (gizzard)	10.9	4.9	0 8
Fowl typhoid	5.1	0.3	0.3
Pneumonia	3.6	0.4	0.2
Chick bronchitis	3.1	2.6	0.7
Colds and coryza	2.5	6.3	10.1
Enteritis	2.4	6.0	7.1
Nutritional dermatitis	2.3	0.2	....
Nephritis	2.1	1.0	0.8
Nutritional paralysis	1.6	0.2	....
Infectious laryngotracheitis	1.4	2.6	2.7
Rickets	1.4	1.3	....
Streptococcus infection	1.1	....	....
Paralysis	....	3.8	14.6
Roundworms (intestinal)	....	1.7	7.9
Tumors	. .	0.7	3.5
Tapeworms	. .	0.2	2.9
Leucosis	....	0.6	2.4

* Hoffmann and Stover.

In case of poisoning, diarrhea trouble, or constipation, give the flock a laxative. For flock treatment of adult birds, use a pound of Epsom salts in two gallons of water per hundred birds. Individual doses of laxatives consist of one-half teaspoonful of Epsom salts in one or two tablespoons of water, or one-half to one teaspoon of castor oil. Liquids may be given with a hollow tube provided with a bulb on one end or with a pipette.

Other control measures to be used will depend upon diagnosis of the disease.

Diagnosis of poultry diseases. A careful observation of external symptoms and autopsy findings are valuable aids in the diagnosis of poultry diseases. Other data needed in arriving at a correct diagnosis include history of the case or outbreak, age of birds affected (Tables 9-3 and 4), per cent of flock affected, housing and yard conditions, the ration being fed, management practices used, and treatment that has been given.

The distribution of causes of mortality in broiler flocks in one of the broiler producing areas is shown in Table 9-5. It may be observed that respiratory diseases and coccidiosis are the principal troubles in broiler flocks. Preventive vaccination programs (p. 333) and the use of coccidostats (p. 313) will reduce losses.

Growing chickens show an increase in coccidiosis, lymphomatosis, infec-

Table 9–4

PRINCIPAL DISEASES OF MATURE CHICKENS AND THE PERCENTAGE DISTRIBUTION AMONG THE AUTOPSIES *

Disease	Age of Birds		
	7-12 Months	1-2 Years	Over 2 Years
Colds and coryza	11.5	7.4	7.7
Roundworms (intestinal)	11.3	10.8	7.2
Coccidiosis	8.6	4.9	1.4
Leucosis	7.8	4.9	3.5
Fowl cholera	6.3	7.7	9.4
Enteritis	5.7	5.3	2.4
Tumors	5.6	7.2	13.4
Ruptured yolk	5.1	5.0	7.5
Paralysis	3.9	2.5	1.1
Pox	2.8	3.2	4.9
Tapeworm	2.7	1.4	1.8
Infectious laryngotracheitis	2.6	2.8	4.6
A-avitaminosis	2.2	1.4	1.2
Roundworms (gizzard)	2.0	3.2	2.0
Lice	2.0	2.2	2.9
Cannibalism	1.6	1.2	0.3
Peritonitis	1.3	1.7	1.6
Nephritis	1.1	1.9	1.4
Salpingitis	1.0	2.0	2.4
Pullorum	0.7	1.8	1.6

* Hoffmann and Stover.

Mature chickens show an increase in tumors and are more likely to s from cholera, fowl typhoid, and pullorum (Table 9–4).

External examination, while helpful, is often insufficient for acc diagnosis. A bird may show certain symptoms that will indicate several eases. As an example, lameness may indicate scaly leg, polyneuritis, vitam deficiency, rickets, bumblefoot, nutritional paralysis, tuberculosis, sod dis parasites, perosis, range paralysis, or injury. External symptoms, aut findings, and the diseases indicated are summarized in Table 9–6.

Post-mortem examination generally adds additional information to obtained from external symptoms.

The bird should be killed by breaking the neck. Cut the skin between vent and rear of the keel around on both sides near the thighs and across ribs. Press the legs away from the body until they are thrown out of joint. the skin forward and to the sides to expose the entire breast and abdom surface (Fig. 9–2).

A cut should then be made through the muscles just back of the br bone and forward through the ribs on each side in the direction of the tachment of the wings. Raise the rear of the keel and push it forwar expose the viscera.

The organs should be examined carefully before removal. Observe the sacs, the pleural and peritoneal linings, the pericardium, and the mesente

Fig. 9–2. Autopsy for diagnosing disease.

for indications of inflammation, unusual deposits, and the presence of abnormal tissue. Look for the presence of fluid, yolk material, or other abnormal substances in the body cavity.

The intestinal tract should be removed and split open with scissors. Look for thickened walls, hemorrhages, ulcers, worms, and other abnormalities. Observe the characteristics of the contents of the intestinal tract. Suspension of a section of the intestine in a jar of warm water helps to reveal small worms.

Open and examine the trachea for inflammation, mucus accumulation, and the presence of parasites.

By checking the abnormalities found with the diseases indicated in Table 9–6, it is often possible to diagnose the disease. Further proof may be secured by microscopic examination of tissues, bacterial cultures, and inoculation tests.

Nutritional Diseases

Unnatural brooding, housing, and feeding conditions; rapid growth; forced production; and the use of processed feeds may often result in nutritional deficiencies.

Vitamin A deficiency. Vitamin A deficiency disease is also known as nutritional roup and avitaminosis A. It may affect poultry of all ages that are deprived of green grass range or other sources of vitamin A.

Table 9–5

CAUSES OF BROILER MORTALITY

Diagnosis	Total Mortality	Per Cent Chicks Started	Per Cent Total Mortality
Respiratory Diseases	9,170	3.5	32.2
Omphalitis	3,038	1.2	10.7
Coccidiosis, caecal	3,010	1.1	10.6
Unsalable	*1,840*	*0.7*	*6.5*
Lymphomatosis, neural	1,449	0.6	5.1
Unfit for examination	1,050	0.4	3.7
Cannibalism	999	0.4	33.5
Coccidiosis, Intestinal	978	0.4	3.4
Stunted birds	923	0.4	3.2
Traumatism	891	0.4	3.1
Laryngotracheitis	707	0.3	2.5
Predators	564	0.2	2.0
Bluecomb	548	0.2	1.9
Gout, visceral	509	0.2	1.8
No diagnosis made	475	0.2	1.7
Lymphamotisis, visceral	317	0.1	1.1
Pericarditis and Peritonitis	276	0.1	1.0
Epidemic Tremors	270	0.1	0.9
Hemorrhage	266	0.1	0.9
Malformations	240	0.1	0.8
Constipation	233	0.1	0.8
Abscesses	226	0.1	0.8
Vovulus on intussusception	138	0.1	0.5
Dropsy	109		
Moniliasis	99		
Perosis	53		
Enterohepatitis	43		
Ulcerations, Intestinal	16		
Ascariasis	2		

* Seeger and Waller

Symptoms among growing chicks include slow growth, ruffled feathers, paleness, drowsiness, staggering gait, inco-ordination of movements, crouching on the hocks, inflammation or dryness of the eyelids, cheesy material in the eyes, emaciation, weakness, and finally death.

Symptoms among hens include cessation of egg production, drowsiness, white cheesy material in the eyes, a nonodorous discharge from the nostrils, emaciation, weakness (Fig. 9–3), staggering gait, whitish droppings, and low resistance against respiratory infections.

Autopsy characteristics of vitamin A deficiency include pustule-like lesions in the mouth and gullet and swollen, grayish kidneys and ureters clogged with uric acid.

More careful study reveals a degeneration of the epithelial lining of the respiratory system and the upper digestive system, nerve degeneration, and an excess of uric acid in the blood.

Prevention of vitamin A deficiency is accomplished by providing green

Table 9–6

DIAGNOSIS OF DISEASES AS INDICATED BY EXTERNAL SYMPTOMS AND AUTOPSY EXAMINATION

Structure, etc.	Abnormalities	Disease Indicated
Comb	Deep red	Cholera, botulism, blackhead
	Purple	Cholera, poisoning, blue comb
	Pale	Parasites, typhoid, tuberculosis, leukemia
	Blister or scabs	Fowl pox
Eyes and nostrils	Exudate in	Colds, roup, vitamin A deficiency, coccidiosis
Mouth and throat	Ulcers in bloody mucus	Roup, fowl pox, thrush, laryngotracheitis
		Infectious bronchitis
Feathers	Unthrifty	Worms, lice, mites, vitamin deficiency
	Falling out	Feather pulling, botulism
Wings	Drooping	Parasites, coccidiosis, vitamin deficiency, bacterial diseases
Legs	Lameness	Injury, gout, bumblefoot, vitamin deficiency, perosis
	Paralysis	Leucosis, tapeworms, coccidiosis, tumors, vitamin deficiency, synovitis
Neck	Limber	Botulism, poisoning, cholera, Newcastle
	Twisted	Worms, poisoning, tumors
Diarrhea	Green	Typhoid
	White	Pullorum, vitamin A deficiency, worms, cholera, coccidiosis
	Yellow	Cholera
	Bloody	Coccidiosis, cholera, hemorrhagic
Crop	Distended	Crop bound, sour crop
Vent	Inflamed, protruding	Prolapse
Weight	Light, emaciated	Parasitic, cholera, coccidiosis, leucosis, tuberculosis, C.R.D.
Temperature	Elevated	Cholera, typhoid, pullorum, tuberculosis, tracheitis
	Subnormal	Botulism, vitamin deficiency
Respiration	Difficult	Bronchitis, gapes, aspergillosis, pneumonia, Newcastle

DIAGNOSIS OF DISEASES AS INDICATED BY EXTERNAL SYMPTOMS AND AUTOPSY EXAMINATION (cont'd.)

Structure, etc.	Abnormalities	Disease Indicated
Liver	Enlarged	Typhoid, leukemia, blackhead
	Spots	Typhoid, coccidiosis, tuberculosis, tumors, blackhead
	Yellow	Chilling, overheating
Intestinal tract	Congestion	Cholera, parasites, coccidiosis, poisons, vitamin B deficiency, hemorrhagic
	Thickened ulcers	Parasites, coccidiosis, tuberculosis, blackhead
	Nodules	Tapeworms, tumors, tuberculosis
Kidneys	Swollen, light colored	Vitamin A deficiency, cholera, typhoid, toxins
Ovary	Discolored or irregular ova	Pullorum, tumors
Heart	Small hemorrhages	Cholera
	Grayish spots	Typhoid
Lungs	Congested with blood	Cholera
	Pus spots	Pullorum, pneumonia
	Green or brown	Mycosis
Trachea and bronchi	Blood and pus	Infectious bronchitis
	Worms in	Gapes
Air sacs	Pus in, thickened	Newcastle, C.R.D., bronchitis

grass range or feeding yellow corn, dehydrated alfalfa meal, and feeds containing carotene or vitamin A (Table 1, Appendix).

Fowls may be cured of vitamin A deficiency disease by feeding cod liver oil, vitamin A acetate, or a solution of carotene in a vegetable oil. The vitamin A requirements of poultry are given on page 265.

Vitamin B_1 deficiency disease. This disease is also known as avitaminosis B and polyneuritis. It is a nerve disease which may affect fowls of all ages deprived of green grass range and fed degerminated grains. Since most rations contain the germs of grains, vitamin B_1 deficiency is of rare occurrence.

Symptoms of vitamin B_1 deficiency include loss of appetite, cessation of growth or production, spastic head contractions (Fig. 9–4), complete paralysis, and high mortality.

Autopsy reveals darkened and shrunken viscera and undigested food in the intestinal tract. The muscles are also darkened and shrunken. Peripheral nerves and those controlling the intestinal movements and secretory glands are partially paralyzed. Carbohydrate metabolism is affected and basal heat production is low.

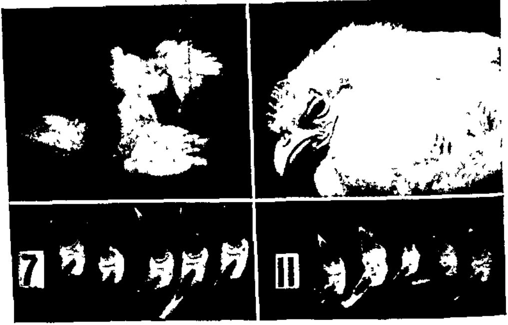


Fig. 9–3. Some fat-soluble vitamin deficiency diseases. Upper left, rickets. Birds walk with a wobbly gait and sit down much of the time. Upper right, vitamin A deficiency. Note the unthriftiness and pale, dry skin about the head and eyes. Lower, (7) normal bones with definite lines of calcification at the joints; (11) rachitic bones with poor calcification at the joints.

Prevention of vitamin B_1 deficiency is accomplished by feeding whole or ground grains containing the germs, wheat bran, and middlings; green grass or alfalfa meal; milk; packing house by-products containing glandular tissue; or other feedstuffs containing vitamin B_1.

Fowls may be cured of polyneuritis by feeding yeast or pure vitamin B_1 (thiamin). Vitamin B_1 requirements of poultry are given on page 265.

Curled toe paralysis. This disease is most often encountered among growing birds kept in confinement or in batteries and fed rations containing a large amount of vegetable protein feeds. It results from a deficiency of riboflavin (p. 231).

Symptoms of curled toe paralysis include slow growth, ruffled feathers, paleness, moving about on the hock joints, toes curling in, and, in advanced stages, lying on the floor with the legs sprawled out.

Riboflavin deficiency among mature birds is indicated by poor hatchability with high embryo mortality the first week, and egg whites with little or no greenish opalescence.

Autopsy may reveal flabby and withered leg muscles and sciatic and brachial nerve degeneration.

Control of curled toe paralysis is accomplished by providing the birds with a green grass range or by feeding good quality alfalfa meal, milk, whey, or other feeds containing riboflavin (Table 1, Appendix).

The disease may be cured by feeding yeast or riboflavin. The riboflavin requirements of poultry are given on page 265.

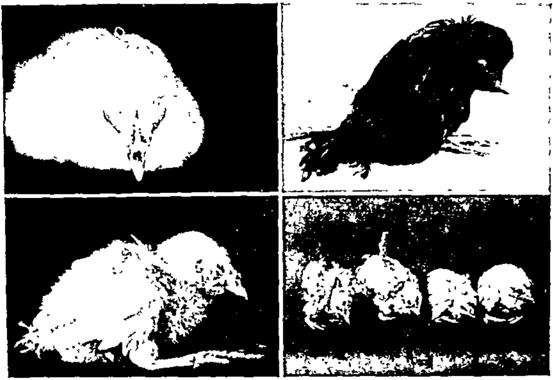


Fig. 9–4. Some vitamin B—G complex deficiency diseases. Upper left, "notched beak" lesion resulting from riboflavin deficiency. (University of California.) Upper right, polyneuritis resulting from vitamin B_1 deficiency. (Ohio Extension Bulletin 115.) Lower left, chick dermatitis resulting from a deficiency of pantothenic acid. (Courtesy L. C. Norris.) Lower right, curled toe paralysis and poor growth resulting from vitamin G or riboflavin deficiency.

Chick dermatitis. It is due to lack of pantothenic acid. It may occur among chicks deprived of green grass and fed rations containing much vegetable protein feeds and little milk, alfalfa, and wheat by-products.

Symptoms of chick dermatitis include scabs or crustlike lesions around the eyes and corners of the mouth and on the feet, granular and constricted margins of the eyelids with a sticky exudate, peeling off of the skin on the toes, and development of wartlike protuberances on the balls of the feet.

Autopsy of chicks affected with chick dermatitis may reveal a puslike substance in the mouth and a grayish exudate in the glandular stomach, eroded lesions in the gizzard, enteritis of the duodenum, portions of the small intestine and ceca distended with gas, and pale-colored liver and kidneys.

Prevention of chick dermatitis is accomplished by feeding green grass or alfalfa meal, packing house by-products rich in glandular tissue, milk, wheat bran, molasses, and other feeds containing pantothenic acid. Calcium pantothenate may also be used (Table 8–1).

Chick dermatitis may be cured by feeding yeast, liver, germs of grains, or pantothenic acid. The requirements of chicks and layers for pantothenic acid are given on page 265.

Nutritional encephalomalacia. This is a disease which affects chicks between two and seven weeks old (Fig. 9–5). It can be produced experimentally by feeding chicks rations high in animal fat content. Birds with apparently

direct sunshine, feeding fish oils or other sources of vitamin D, and by irradiation under ultraviolet lights. The vitamin D requirements of chickens are given on page 265.

Perosis. This is also known as slipped tendon or hock disease. It is a bone disease affecting the hock joints of growing birds. It occurs most frequently among chickens which are raised on wire or in confinement and fed rations of high mineral content.

Symptoms of perosis include a slight puffiness of the tissues about the hock joint; discoloration due to subcutaneous hemorrhage; or crooked legs.

Pathology of perosis is indicated by an irregular line of ossification of the end of the tibia at the hock joint and the Achilles tendons slipped from the condyles.

Prevention of perosis is accomplished by raising chickens on range or in confinement on litter rather than on wire; by avoiding an excess of phosphorus in the ration; and by feeding alfalfa, oats, middlings, rice bran, or a trace of manganese in the ration.

Chickens in the early stages of perosis may return to normal if the system of feeding and management is corrected.

The mineral requirements of growing chickens are given on page 265.

Gout. Gout is a disease that generally affects mature birds, fed a high protein ration and given little exercise. The disease is characterized by swollen joints, chalk-like covering of the viscera and swollen pale kidneys. The trouble may be corrected by reducing the protein intake and providing range.

Indigestion. This is the lack or failure of digestion. Mechanical obstruction to the passage of food may be a cause of indigestion.

Crop-bound trouble may result from irregular feeding, partial starvation followed by giving feed before water, change from confinement to range, and feeding coarse, dry, fibrous, or decayed feed.

Crop-bound condition may be relieved by injecting water into the crop, loosening the material by massage, and emptying the crop by gentle pressure on it with the head of the bird pointing downward. If this fails, it will be necessary to open the crop by making an incision on the upper part of the organ. Pull the skin which covers the crop wall to one side and cut through it; then push it back and cut through the crop wall. Remove the contents and sew up the crop membrane with ordinary thread which has been dipped in tincture of iodine. Sew up the skin separately. Feed soft feed for a few days.

Sour crop is indicated by distention of the crop with gases. The condition may be relieved by injection of soda water (two teaspoons of baking soda in a pint of water) into the crop and forcing the material out by massaging while holding the bird by the feet and the head down.

Constipation may be relieved by giving Epsom salts at the rate of one pound per hundred hens in two gallons of drinking water or in wet mash. Individual dosage consists of one-half teaspoon of Epsom salts in one to two tablespoons of water It may be given with a hollow tube with a bulb on the end of it.

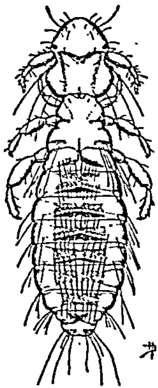
Poisoning. Cases of poisoning among poultry are seldom encountered. The bird's sense of taste will usually protect it if it is well fed and kept away from unusual, alluring objects. Cases of poisoning are more common among birds allowed to run at will than among those kept in confinement.

Symptoms of poisoning include sudden appearance of a large number of birds with dark red combs, elevated temperature, weakness, wobbly gait, prostration, limberneck, and high mortality.

Autopsy findings in case of poisoning may reveal a parboiled appearance of the crop, severe inflammation of the intestinal tract, and the presence of poisonous substances in the crop or gizzard.

Causes of poisoning among fowls include spray materials; rat poisons; excessive amounts of medicinal products, such as bichloride of mercury or copper sulphate in the drinking water; overdoses of parasite remedies, such as nicotine sulphate and kamala; dusting and fumigating compounds, such as cyanides; decomposed animal tissues; paint skins; and rose chafers.

Control of poisoning may be accomplished by shutting the birds off range, giving a laxative (p. 288), and changing the ration.



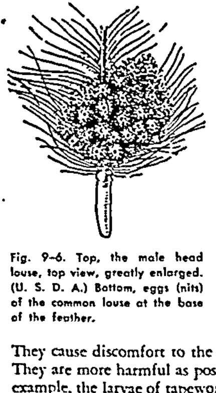


Fig. 9–6. Top, the male head louse, top view, greatly enlarged. (U. S. D. A.) Bottom, eggs (nits) of the common louse at the base of the feather.

External Parasites

Flies, lice, mites, ticks, and fleas are the most important of the many species of external parasites that infest poultry. They cause discomfort, skin irritation, loss of plumage, stunted growth, and decreased egg production. External parasites may also serve as carriers of bacterial and virus diseases from one bird to another.

Flies. Flies are as much of a menace to the health of poultry as they are to that of people. They cause discomfort to the birds by their biting and blood-sucking habits. They are more harmful as possible carriers of disease germs and parasites, for example, the larvae of tapeworms (p. 311).

Flies reproduce by laying eggs in damp manure, wet litter or straw, vegetable wastes, and similar places. The minute creamy white eggs hatch in 1 to 3 days. As soon as they are hatched, the larvae begin feeding on bits of the moist breeding place material. When hatched, the larvae are translucent and not easily seen. When full grown, they are pale yellow or nearly white

the same disease have been observed under practical farm conditions and fed many different home-mixed and commercial feeds.

Symptoms of nutritional encephalitis include ataxia, tremors, retraction of the head, spasms of the legs, inco-ordination, prostration, stupor, and finally death.

Pathology of nutritional encephalomalacia is indicated by swelling and softening of the cerebellum and sometimes other parts of the brain, edema of the brain covering, minute hemorrhages on the surfaces of the brain, and greenish to brownish coloration and shrinkage of the necrotic areas.

Apparently the chief causes of the trouble are rancid fats or unsaturated fatty acids from fish sources, animal products in general, and perhaps even some plant products in the ration.

Nutritional encephalomalacia can be prevented by reducing the total level of unsaturated fatty acids in the ration or making sure that it contains 7 to 11 I. U. of vitamin E (alpha tocopheryl acetate) per pound. The addition of an antioxidant (p. 234), will also protect against the trouble.

Vitamin K deficiency disease. Vitamin K deficiency results in a blood disease characterized by hemorrhages and slow clotting time of the blood. It affects growing chicks deprived of natural feeds and may also affect mature birds.

Symptoms of vitamin K deficiency include paleness or anemia, excessive hemorrhage from minor wounds, cannibalism, and feather picking.

Pathology of vitamin K deficiency is indicated by small hemorrhages beneath the skin and elsewhere in the body. The hemoglobin content of the blood is low and the clotting time of the blood is delayed.

Prevention of vitamin K deficiency is accomplished by providing birds with green grass range or by feeding alfalfa, meat scraps, fish meal, or menadione (p. 232) in the ration.

Hemorrhagic disease. This is a relatively new disease occurring among chickens 6–10 weeks old, raised in confinement and fed antibiotic and coccidiostatic drugs. The symptoms and pathology are much the same as in vitamin K deficiency. The disease may be produced experimentally by feeding higher than the recommended dosage of sulfaquinoxaline to 3–6 week old chickens. The drug probably interferes with vitamin K utilization. The trouble may be corrected by removal of the drug, feeding 3 to 5 per cent alfalfa or adding 5–20 gram of vitamin K (menadione) per ton of feed.

Rickets. This is a vitamin D deficiency disease which inhibits normal mineral assimilation. It affects birds of all ages that are kept in confinement unless vitamin D is supplied in some form.

Symptoms of rickets among growing birds include a wobbly gait, sore joints, a tendency to squat down much of the time, ruffled feathers, poor growth, crooked bones, emaciation, and death.

Rickets among mature birds is indicated by low egg production, thin eggshells, poor hatchability, crooked breastbones, and temporary paralysis.

Pathology of rickets is indicated by soft, spongy bones of low ash content; wide zone of uncalcified tissue at the ends of the tibia (Fig. 9–3); calluses

Fig. 9–5. Miscellaneous nutritional troubles. Upper left, perosis, also known as "slipped tendon" and hock disease. Upper right, beak necrosis. Feed sticking in the beak has caused the deformed beak. Lower left, "crazy chick" disease. Nutritional encephalomalacia shows similar symptoms. Lower right, gizzard erosion: top, normal gizzard lining; bottom, eroded lining. (Courtesy W. B. Esselen, Massachusetts State College.)

at the junctures of the sternal and vertebral portions of the ribs, and enlarged thyroids.

Prevention or cure of rickets is accomplished by providing chickens with

direct sunshine, feeding fish oils or other sources of vitamin D, and by irradiation under ultraviolet lights. The vitamin D requirements of chickens are given on page 265.

Perosis. This is also known as *slipped tendon* or *hock disease*. It is a bone disease affecting the hock joints of growing birds. It occurs most frequently among chickens which are raised on wire or in confinement and fed rations of high mineral content.

Symptoms of perosis include a slight puffiness of the tissues about the hock joint; discoloration due to subcutaneous hemorrhage; or crooked legs.

Pathology of perosis is indicated by an irregular line of ossification of the end of the tibia at the hock joint and the Achilles tendons slipped from the condyles.

Prevention of perosis is accomplished by raising chickens on range or in confinement on litter rather than on wire; by avoiding an excess of phosphorus in the ration; and by feeding alfalfa, oats, middlings, rice bran, or a trace of manganese in the ration.

Chickens in the early stages of perosis may return to normal if the system of feeding and management is corrected.

The mineral requirements of growing chickens are given on page 265.

Gout. Gout is a disease that generally affects mature birds, fed a high protein ration and given little exercise. The disease is characterized by swollen joints, chalk-like covering of the viscera and swollen pale kidneys. The trouble may be corrected by reducing the protein intake and providing range.

Indigestion. This is the lack or failure of digestion. Mechanical obstruction to the passage of food may be a cause of indigestion.

Crop-bound trouble may result from irregular feeding, partial starvation followed by giving feed before water, change from confinement to range, and feeding coarse, dry, fibrous, or decayed feed.

Crop-bound condition may be relieved by injecting water into the crop, loosening the material by massage, and emptying the crop by gentle pressure on it with the head of the bird pointing downward. If this fails, it will be necessary to open the crop by making an incision on the upper part of the organ. Pull the skin which covers the crop wall to one side and cut through it; then push it back and cut through the crop wall. Remove the contents and sew up the crop membrane with ordinary thread which has been dipped in tincture of iodine. Sew up the skin separately. Feed soft feed for a few days.

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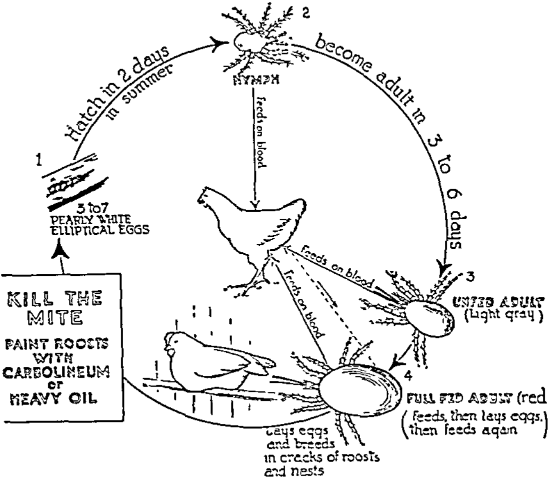

U. S. D. A.

Fig. 9–7. The life cycle of the common roost or red mite.

at night when on the roost and suck its blood. After feeding, the mites appear red. They crawl back to their hiding places and lay eggs. A female lays about four eggs in twenty-four hours and feeds again before laying another four eggs. The cycle may be repeated eight or more times. The eggs hatch in about two days during warm weather. The young mites reach maturity in about a week (Fig. 9–7).

One should keep a close watch for mites in the summertime and at all times of the year in heated houses. The birds attacked by mites appear unthrifty and pale as a result of the loss of blood. Pens badly infested with mites have a characteristic odor. New houses and equipment are just as likely to become infested as old ones. Patches or colonies of the mites may be seen by lifting up the perches and looking underneath them or by loosening caked manure or litter about the perches or nests. These appear as gray or reddish masses of the small insects.

Control of the red mite may be accomplished by providing dry, well-ventilated, and well-lighted houses and keeping them free of wild birds. In case mite infestation is found, the roosts, adjacent walls, dropping boards, feed roosts, outside surfaces of nests, and other harborages should be sprayed or painted (Table 9–7). The mites are destroyed in 3 or 4 days by coming

and about four-fifths inch long. The larvae (maggot) period lasts about 11 days under favorable damp, warm, dark conditions. The larvae go through a contracted, thickened pupal state which requires another 10 or 12 days. Under favorable conditions flies develop from eggs to adults in about 3 weeks. In cold climate, flies generally survive the winter in the larval or pupal states.

Fly control may be accomplished by destroying the damp breeding places or by keeping them screened. Dry or wet baits, and wall and dropping sprays may be used (Table 9–7). Commercial mixtures of fly killers are on the market. They should be used according to the directions of the manufacturers.

Lice. Over two thousand species of bird lice have been described, and of these, forty or fifty may be found on poultry. An individual may harbor several species. They are generally referred to as body lice, head lice, shaft lice, wing lice, etc.

Characteristics of lice show them to be small, flattened insects seldom more than one-eighth inch in length, and yellowish or gray in color (Fig. 9–6). They live on birds on the skin and at the base of the feathers, and spend their entire life cycle there. Lice have biting and cutting mouth parts and feed upon scales of the skin or bits of feathers. The biting of lice, together with their sharp claws and spiny structure, causes considerable discomfort to birds on which they live. Lice seldom leave an individual except by accident or to migrate to another individual of the same species. They cannot live more than a week or so away from the body of the fowl. Lice lay eggs at the base of feathers. Body warmth hatches them, and they mature in 10–20 days after hatching.

The body louse is probably the most common parasite of poultry. It is most easily located in the region below the vent. In cases of bad infestation, the body louse may also be found on the back, breast, and under the wings. Body lice cause skin irritation and may produce scabs and blood clots. They infest chickens, turkeys, and other species of poultry.

The head louse is found on the head and neck of chickens and turkeys. It is dark gray in color and about one-tenth inch long. It may cause serious damage among young chicks and poults

The shaft louse is found along the shaft of the feathers and seldom on the skin. It feeds on the barbs of the feathers and the scales along the shafts.

Turkeys, ducks, geese, pigeons, other fowls, and wild birds are infested with several other species of lice

Control of lice may be accomplished by dusts, sprays, or perch paints (Table 9–7), if used according to the directions of the manufacturers. Since the insecticides generally used do not kill the lice eggs, it is often advisable to repeat the treatment in 1 to 2 weeks, to kill the young lice that have hatched

The roost mite. The roost mite is a very small gray insect which lives in cracks and crevices about the porches, under boards, and in fecal material and litter near the perches and nests. Great numbers of mites attack a single bird

in contact with the insecticide. A thick crust of manure on the roosting areas will reduce the effectiveness of the treatment.

The Northern fowl mite (feather mite). This external parasite looks like the red roost mite but its life history is different. It spends its life cycle of 8 to 12 days on birds but may be found in nests. The feather mites move quickly. They congregate at the base of the plumage near the vent, often resulting in a soiled appearance of the feathers. The blood sucking habits of the mites may irritate the skin severely. Heavy infestations may develop in a short time.

Control of the northern fowl mite is difficult. A malathion dust may be used in the nests and on the roosts and adjacent areas (Table 9–7). The birds may be dusted or sprayed with malathion as for lice. The treatment may need to be repeated at 10 to 14 day intervals until the mites have been eradicated.

An ointment, consisting of one part of pulverized napthalene flakes and two parts of vaseline, rubbed into the skin and around the vent and tail will rid birds of feather mites.

The depluming mite (*Cnemidocoptes gallinae*). The depluming mite is a small itch mite which lives at the base of the feather. The intense irritation causes the bird to pull out its own feathers. In severe cases the bird may loose nearly all of its feathers except the large ones on the wings and tail.

Repeated applications of sulphur ointment (one part sulphur in four parts of vaseline or lard) will destroy the depluming mite.

Dipping birds in a tub of water containing two ounces of orchard spray sulphur and one ounce of laundry soap to each gallon will destroy the depluming mite. The treatment should be used during a warm day or in a warm house and the birds thoroughly soaked in order that the material will reach the base of the feathers and the skin.

The scaly leg mite. This is a small itch mite which burrows under the scales of the shanks. The severe irritation causes an accumulation of grayish, dry debris and a loosening of the scales. The shanks appear to be enlarged and rough (Fig. 9–8). In severe infestations the bird may become lame and the feet deformed. Chickens, turkeys, other species of poultry, and game birds may become infested by the scaly leg mite.

The life cycle is spent on the bird. The mites lay eggs as they burrow their channels beneath the scales. The eggs are hatched and the young grow to maturity beneath the scales of the shanks.

Birds may be cured of scaly leg mite infestation by soaking and washing off the crusts and scales with warm soapy water, drying the shanks, and then dipping them in a mixture of one part kerosene and two parts of raw linseed oil.

Chiggers. The small, almost microscopic chiggers which annoy man may also infest poultry that run on range. They collect in groups, cause extreme irritation, and small abscesses are formed where they feed. Chiggers may cause mortality among growing stock and unthriftiness among adult stock.

Chigger infestations may be prevented by hatching chicks early and by keeping them off ranges where the mites occur.

Table 9–7

INSECTICIDES FOR CONTROL OF POULTRY EXTERNAL PARASITES AND FLIES *

Insect	Insecticide	Dosage	Use
Redbugs	DDT	2.5% spray	Thoroughly spray the house.
Fleas	DDT	2.5% spray	Thoroughly spray the house.
	Malathion	4.0% dust	Apply to litter 1 lb. per 50 sq. ft.
Lice	Lindane	0.5–1.0% spray	Remove birds. Spray all surfaces. Return birds when dry.
	Nicotine sulfate	1 pint per 100 ft. of roost	Paint in thin line on roosts. Apply ½ to 1 hour before dark. Ventilate well.
	Malathion	4% dust	1 lb. per 40 sq. ft. litter. 1 lb. per 100 birds with shaker can. Repeat in 4 weeks.
		0.5% wall spray	Walls, equipment, litter.
		0.5% bird spray	Spray birds in addition to premises at rate of 1 gallon per 100 uncaged birds or 1 quart per 75 caged layers.
Northern feather mite	Malathion	4% dust	Apply to roosts, nests and litter at rate of 1 lb./50 sq. feet. Spray birds with Malathion as for lice.
Poultry red mite	Lindane	0.5 to 1.0% spray	Remove birds. Spray all surfaces. Return birds when dry. Repeat in 10–14 days.
	Malathion	Same as for lice	Same as for lice. Repeat in 10-14 days.
	Carbolineum	Undiluted	Paint roosts, nests and feeders. Allow to dry 3–7 days. Repeat annually
Flies	*Dry baits*		
	Diazinon	1%	Purchase commercially prepared bait. Apply daily for 3 days at the rate of 1 oz. per 1000 sq. ft. Do not use near food, feed, water or animals
	Dipterex	1–2%	
	Malathion	1–2%	
	Liquid baits		
	Diazinon	0.1%	Use in water containing 1 cup of sugar or syrup per gallon. Sprinkle daily on clean floor or burlap bags, at rate of one gallon per 1000 sq. ft.
	Dipterex	0.1%	
	Malathion	0.1%	
	Wall sprays		
	Diazinon	0.5 to 1.0%	Apply to walls or ceilings but not in food rooms or on animals. Apply at rate of 1–2 gallon per 1000 sq. ft.
	Malathion	1.0 to 2.0%	Same as for Diazinon.
	Breeding areas		
	Diazinon	1.0% spray	Spray manure piles, cones under cages and pits every 3 or 4 weeks.
	Malathion	2.0% spray	Same as for Diazinon.

* Ohio Agricultural Extension Service.

in contact with the insecticide. A thick crust of manure on the roosting areas will reduce the effectiveness of the treatment.

The Northern fowl mite (feather mite). This external parasite looks like the red roost mite but its life history is different. It spends its life cycle of 8 to 12 days on birds but may be found in nests. The feather mites move quickly. They congregate at the base of the plumage near the vent, often resulting in a soiled appearance of the feathers. The blood sucking habits of the mites may irritate the skin severely. Heavy infestations may develop in a short time.

Control of the northern fowl mite is difficult. A malathion dust may be used in the nests and on the roosts and adjacent areas (Table 9–7). The birds may be dusted or sprayed with malathion as for lice. The treatment may need to be repeated at 10 to 14 day intervals until the mites have been eradicated.

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Dipping birds in a tub of water containing two ounces of orchard spray sulphur and one ounce of laundry soap to each gallon will destroy the depluming mite. The treatment should be used during a warm day or in a warm house and the birds thoroughly soaked in order that the material will reach the base of the feathers and the skin.

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The life cycle is spent on the bird. The mites lay eggs as they burrow their channels beneath the scales. The eggs are hatched and the young grow to maturity beneath the scales of the shanks.

Birds may be cured of scaly leg mite infestation by soaking and washing off the crusts and scales with warm soapy water, drying the shanks, and then dipping them in a mixture of one part kerosene and two parts of raw linseed oil.

Chiggers. The small, almost microscopic chiggers which annoy man may also infest poultry that run on range. They collect in groups, cause extreme irritation, and small abscesses are formed where they feed. Chiggers may cause mortality among growing stock and unthriftiness among adult stock.

Chigger infestations may be prevented by hatching chicks early and by keeping them off ranges where the mites occur.

Dogs, cats, and other carriers of fleas should be kept away from the poultry houses. In case of infestations, the houses should be cleaned and the houses and yards sprayed with DDT (Table 9–7).

Fowls may be treated with the sulphur ointment (1 part sulphur in 4 parts lard or vaseline).

Internal Parasites

Internal parasites of poultry include the round and flat worms. There are no symptoms specific enough for diagnosis. Birds should be autopsied and the worms found. Most species of worms are large enough to be seen with the naked eye.

Worms cause stunted growth, emaciation, weakness, and death among growing stock, and poor vigor and low egg production among mature birds. The extent of the injury will depend upon the age when infested and the severity of the infestation. Worms cause obstruction to the passage of food; injure body tissues, thereby making birds more susceptible to bacterial and virus infections; produce toxins; and use the bird's food for their own growth and reproduction.

Worms reproduce by eggs which are passed out with the droppings. They must undergo incubation outside the body or in an intermediate host before they are infective. Birds become infested by eating material from contaminated soil or litter and by eating intermediate hosts such as insects and worms.

Large roundworms (*Ascaridia lineata*). Large roundworms may be found in birds of all ages, but cause most serious damage among birds under three months of age.

Symptoms of large roundworm infestation are unthriftiness, drooping or sagging of the wings, paleness of the head, and emaciation among young stock. Lowered egg production and emaciation are symptoms among mature birds.

Autopsy of birds infested with large roundworms reveals grayish-white slender roundworms one and one-half to four inches in length in the small intestine. They may be so numerous as to completely plug the intestine (Fig. 9–9). They may penetrate the intestinal wall during growth, thereby causing injury and loss of blood, and permitting bacterial infection.

Occasionally a roundworm may wander up the oviduct from the cloaca and become enclosed in an egg.

Life history of the large roundworm is illustrated in Figure 9–10. The worms lay microscopic eggs in the intestinal tract which are passed to the outside with the droppings of the bird. Under favorable conditions of warmth and moisture they incubate and become infectious in from ten to sixteen days. The embryonated worm is liberated from the shell when the egg is eaten along with other material picked up from contaminated soil or litter. The young worms may burrow into the wall of the intestine for a period after hatching and cause considerable damage to the lining. They then return to the intestine and grow to maturity in about two months from date of hatching.

Fig. 9–8. Legs of a chicken as they commonly appear with scaly leg.

Frequent light dusting with flowers of sulphur will keep the chigger mite infestation under control. In case of severe infestation, the application of sulphur ointment as used for the depluming mite (p. 303) is effective.

The fowl tick (*Argas persicus*). The fowl tick generally infests chickens but may also infest other species of poultry. It is a blood-sucking insect about one-fourth inch in length. The life history of ticks is much like that of the roost mite in that they hide and lay eggs in cracks or secluded spots and attack the birds and suck blood. Ticks may live for many months without food.

A wood preservative containing anthracene oil or an oil spray applied to the perches as in the treatment for the roost mite (p. 301) is effective against tick infestation.

Fleas (*Echidnophaga gallinacea*). The chicken flea, or sticktight flea, is a common parasite of poultry in the southern states. The fleas attach themselves to the comb, face, earlobes, and wattles and remain there for several days. They lay eggs while attached to the birds. The eggs incubate in the litter or on the ground in about a week. The young fleas feed upon the droppings. They go through a series of developmental stages and then attack birds. The entire life cycle requires thirty to sixty days.

Flea infestation is rather hard to prevent because the fleas are carried by dogs, cats, rats, and wild birds. Dust on the floor and the soil under the poultry house are ideal places for flea development.

Dogs, cats, and other carriers of fleas should be kept away from the poultry houses. In case of infestations, the houses should be cleaned and the houses and yards sprayed with DDT (Table 9–7).

Fowls may be treated with the sulphur ointment (1 part sulphur in 4 parts lard or vaseline).

Internal Parasites

Internal parasites of poultry include the round and flat worms. There are no symptoms specific enough for diagnosis. Birds should be autopsied and the worms found. Most species of worms are large enough to be seen with the naked eye.

Worms cause stunted growth, emaciation, weakness, and death among growing stock, and poor vigor and low egg production among mature birds. The extent of the injury will depend upon the age when infested and the severity of the infestation. Worms cause obstruction to the passage of food; injure body tissues, thereby making birds more susceptible to bacterial and virus infections; produce toxins; and use the bird's food for their own growth and reproduction.

Worms reproduce by eggs which are passed out with the droppings. They must undergo incubation outside the body or in an intermediate host before they are infective. Birds become infested by eating material from contaminated soil or litter and by eating intermediate hosts such as insects and worms.

Large roundworms (*Ascaridia lineata*). Large roundworms may be found in birds of all ages, but cause most serious damage among birds under three months of age.

Symptoms of large roundworm infestation are unthriftiness, drooping or sagging of the wings, paleness of the head, and emaciation among young stock. Lowered egg production and emaciation are symptoms among mature birds.

Autopsy of birds infested with large roundworms reveals grayish-white slender roundworms one and one-half to four inches in length in the small intestine. They may be so numerous as to completely plug the intestine (Fig. 9–9). They may penetrate the intestinal wall during growth, thereby causing injury and loss of blood, and permitting bacterial infestion.

Occasionally a roundworm may wander up the oviduct from the cloaca and become enclosed in an egg.

Life history of the large roundworm is illustrated in Figure 9–10. The worms lay microscopic eggs in the intestinal tract which are passed to the outside with the droppings of the bird. Under favorable conditions of warmth and moisture they incubate and become infectious in from ten to sixteen days. The embryonated worm is liberated from the shell when the egg is eaten along with other material picked up from contaminated soil or litter. The young worms may burrow into the wall of the intestine for a period after hatching and cause considerable damage to the lining. They then return to the intestine and grow to maturity in about two months from date of hatching.

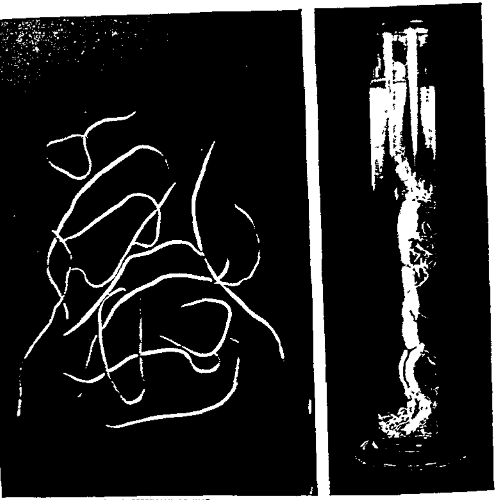

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Fig. 9–9. Roundworms from the small intestines of a chicken and a portion of intestine filled with roundworms.

Prevention of large roundworm infestation is accomplished by the use of clean range, elimination of wet, shady places in the chicken yard; isolation of young birds from old ones; avoidance of wet litter in the brooder house; and the use of a starting and growing ration of good protein and vitamin content.

Treatments may be used for roundworm infestation, but they will be only temporarily effective unless the source of infestation is eliminated. Some of the treatments are as follows:

No. 1. Give each bird a No. 2 capsule containing .35 gram of a mixture of 6.6 cubic centimeters of a 40-per cent nicotine sulphate and 16 grams of Lloyd's alkaloidal reagent (a selected fuller's earth).

No. 2. Give each mature bird one cubic centimeter of tetrachlorethylene or carbon tetrachloride in a gelatin capsule or with a pipette. Reduce size of dosage for smaller birds. Care must be taken that the drug does not get into the lungs.

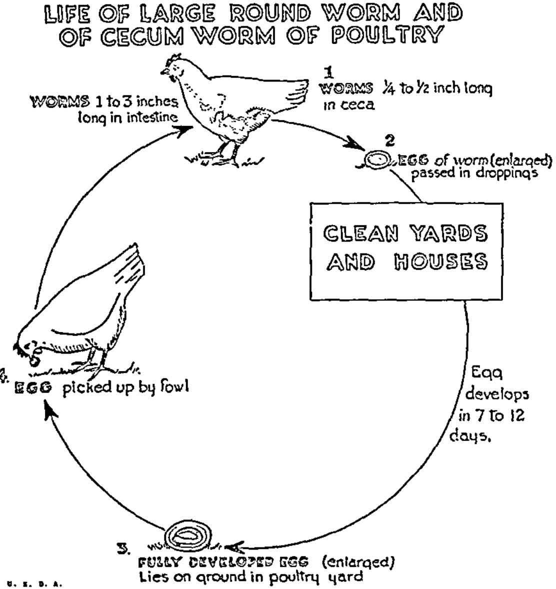

Fig. 9–10. Life cycle of the large roundworm and cecum worm of poultry. Note the incubation stage in soil.

No. 3. Individual dosage of 0.25 to 0.5 gram of piperazine hexahydrate or citrate in a capsule, or 0.4 per cent in the mash feed for a single day's feeding may be used. It may be repeated at monthly intervals if necessary.

No. 4. A preventive flock treatment is the addition to the mash of 2 per cent by weight of tobacco dust containing at least 1.5 per cent of nicotine, and feeding this mixture to the flock for a period of three or four weeks. Treatment may be repeated at three-week intervals as often as necessary.

Individual treatments are more effective than flock treatments In the latter method, the birds that need the treatments the worst have a poor appetite and do not eat enough of the material for it to be effective.

For a few days following the administration of vermifuges, the birds should be confined so that the worms and eggs expelled may be removed with the litter and burned.

Gapeworms (*Syngamus trachea*). Gapeworms cause "gapes" or a gasping for breath among chicks during the brooding period.

Symptoms of gapeworm infestation are dullness, ruffled feathers, loss of appetite, stretching of the neck with a yawnlike opening of the beak, convulsive shaking of the head, sneezing cough, expulsion of frothy saliva from the beak, and high mortality.

Autopsy examination of the trachea of birds infested with gapeworms reveals inflammation of the lining, an accumulation of mucus, and the presence of small, slender, reddish roundworms one-fourth to one and one-half inches in length, clinging to the inner lining.

The *life cycle* of gapeworms is direct. The microscopic eggs are coughed up, swallowed, and expelled with the feces. They undergo incubation and may hatch outside the body. Either the embryonated eggs or the worms cause infestation when contaminated soil, litter, feed, or water is consumed. The young worms reach the lungs within a week and in another week or so will have matured and become imbedded in the trachea.

Earthworms play an important part in the spread of gapeworms. The eggs may be eaten by earthworms and these in turn by fowls. Turkeys and guinea fowls may carry gapeworms throughout their whole life and thus may serve as a source of infestation for chicks and young turkeys.

Control measures include clean range, isolation of young stock from old birds, and keeping birds shut up until the dew has dried off and the earthworms have crawled back into the soil.

Treatment consists of inhaling barium antimonyl tartrate dust for 15 to 20 minutes. Place the birds in a closed box. Pump in about one ounce of the dust to each 8 cubic feet of box space with a dust gun. Then tilt the box back and forth so that the birds will keep the dust stirred up by wing movement and will breathe more vigorously.

Cecal worms (***Heterakis gallinae***). The common cecal worm of poultry occurs in the ceca of chickens, turkeys, ducks, and geese. It is a small, white, roundworm three-tenths to one-half inch long and may occur in very large numbers, causing a serious inflammation of the ceca, especially in young chicks. This parasite may also carry the protozoan which causes blackhead in turkeys.

The *life cycle* is very similar to that of the large roundworms. The eggs voided in the droppings become embryonated in seven to twelve days. When taken into the body, they hatch in the small intestine and become encysted in the walls of the cloaca. After a short time they return to the lumen of the ceca and develop into adults. The entire life cycle requires eight or nine weeks.

The eggs have a thick shell and may remain infectious after a year or more in the soil. Earthworms ingest cecal worm eggs, and birds may become infested by eating these worms or by ingesting food contaminated with their excreta.

Prevention measures against cecal worm infestation include general sanitary measures, rotation of yards, and isolation of young chicks from old birds.

Treatment for cecal worm infestation is the use of a mash containing .5 per cent phenothiazine. The mixture is moistened with water to make a crumble mash and fed after the regular feed is withheld for two or three hours. The use of this mash for a six- to eight-hour period will remove nearly all of the cecal worms.

Small roundworms (*Capillaria annulata*). As with the large roundworms, small roundworm infestations may be found in chickens, turkeys, and game birds of all ages.

Symptoms of small roundworm infestation include droopiness, anemia, muscular weakness, loss of appetite, foul breath, emaciation, twisting of the neck, and paralysis of the legs.

Autopsy of birds infested with small roundworms reveals the presence of delicate, slender, colorless, hairlike worms one-half to one inch in length in the gullet, crop, small intestine, or ceca. The worms are hard to see with the naked eye unless the sections of the intestinal tract are suspended in clear water. Crop infestation results in milky fluid crop contents with a foul odor, inflammation and thickening of the crop wall, and the formation of a necrotic false membrane. Intestinal species may be found in the lumen of the intestine or threaded in the surface of the mucous membrane.

Life history of small roundworms varies with the species. It may be direct as in the case of the large round and ceca worms or it may require earthworms as intermediate hosts.

Prevention of small roundworm infestation should include the same sanitary measures used for large roundworm control.

Treatment for small roundworm infestation is only partially effective. Carbon tetrachloride, given in one cubic centimeter doses, as for roundworms, and repeated in seven days is partially effective.

Gizzard worms (*Cheilospirura hamulosa*). Gizzard worms infest chickens, turkeys, water fowls, and game birds.

Symptoms of gizzard worm infestation include dullness, loss of appetite, emaciation, weakness, and death.

Autopsy of birds infested with gizzard worms reveals the presence of slender, reddish, roundworms one-half to three-fourths inch in length in the musculature of the gizzard near the entrance of the proventriculus. Nodules may be present on the surface of the gizzard in this region.

The *life cycle* of the gizzard worm requires the grasshopper as an intermediate host. The eggs, passed out with the droppings, are eaten by grasshoppers. The larvae hatched from the eggs undergo development in the muscles of the grasshopper and become infective in a few weeks. If the grasshopper is eaten by a susceptible bird, the larvae are set free and grow in the gizzard of the fowl and reach maturity in two or three months.

Prevention of gizzard worm infestation includes frequent removal of the litter and droppings and confinement of birds to runs with short, thick vegetation rather than free range having tall, dry vegetation.

Treatment for gizzard worm infestation is only partially effective. The carbon tetrachloride treatment used for small roundworms may be used.

Eye worms (*Oxyspirura mansoni*). Eye worms may infest chickens, turkeys, and wild birds. They are most common in the southern states.

Symptoms of eye worm infestation include constant winking of the eye, frequent rubbing of the head on the feathers of the wing, the scratching of the eye with the foot, puffy and inflamed eyes, and a discharge from the eyes and nose pasted over the feathers.

Autopsy of birds infested with eye worms reveals small, white, threadlike worms approximately one-half inch long beneath the nictitating membrane of the eye. Firm pressure applied to the tear sac at the inner corner of the eye will cause the worms to wiggle out over the eyeball, where they may be seen.

The *life history* of the eye worm requires an intermediate host. The cockroach is one of the hosts. It eats the eggs and the larvae develop in its body. When fowls eat infested cockroaches, the worms are liberated in the crop. The worms crawl up the gullet to the mouth and then through the tear ducts to the eye.

Prevention of eye worm infestation consists of eradication of hiding places for cockroaches such as boxes, boards, and other unnecessary equipment. Frequent removal of litter and droppings will also help remove the sources of the worm eggs for the roaches.

Treatment for eye worm infestation consists of dropping two or three drops of a 5 per cent solution of butyn into the eye as an anesthetic; lifting the nictitating membrane and putting a drop or two of 5 per cent creolin directly on the worms; and, immediately after applying the creolin, washing the eye thoroughly with warm water.

Glandular stomach worms (*Tropisurus americanus*). The glandular stomach worm affects chicks during the growing period.

Symptoms of glandular stomach worms include poor appetite, weakness, anemia, emaciation, diarrhea, and death.

Autopsy of birds infested with glandular stomach worms reveals a swelling of the proventriculus, inflammation, hemorrhage, and destruction of the glands.

The *life history* of glandular stomach worms requires grasshoppers and cockroaches as intermediate hosts. Eggs picked up by these insects hatch within their bodies and the larvae develop in their muscles. When fowls eat the infested insects, the larvae are liberated and enter the glands of the proventriculus.

Prevention of glandular worm infestation consists of frequent removal of droppings and litter and keeping fowls away from cockroaches and grasshoppers.

There is no effective treatment for glandular worm infestation.

Tapeworms (*Cestoda*). Tapeworms infest chickens, turkeys, and other species of poultry and wild birds. Infestations appear to be most noticeable in the fall or early winter. Tapeworm infestation is more detrimental among young than old birds.

Symptoms of tapeworm infestation include droopiness, ruffled feathers, diarrhea, weakness, paleness of comb, twisting of the neck in unnatural positions, and lameness or paralysis in one or both legs.

Autopsy of birds infested with tapeworms reveals the presence of flat, white, segmented, ribbon-like worms fastened to the wall of the small intestine (Fig. 9–11). They may vary from microscopic dimensions in some species to ten inches in length in others. Numerous protuberances or nodules may be observed on the outer surface of the small intestine opposite the joints of attachment of species of small tapeworms to the inner lining. The nodules may consist of pus or greenish-yellow necrotic material. Intestinal catarrh is common.

The *life history* of tapeworms requires intermediate hosts such as flies, earthworms, beetles, grasshoppers, and ants (Fig. 9–12). The worms attach themselves to the intestinal wall by means of heads (scolexes) provided with hooks or suckers, or both. Segments containing eggs grow from the head or neck part of the worm. The segments break off and pass out with the droppings. The intermediate hosts eat the eggs, hatch them, and develop the young worms into a bladder worm stage. When the flies, earthworms, grasshoppers, or other carriers of tapeworm larvae are eaten by fowls, all except the heads of the bladder worms are digested. The heads attach themselves to the mucous membrane of the small intestine where they develop segments and start another generation.

Prevention of tapeworm infestation consists of using clean range or keeping birds in confinement, raising young birds separate from old birds and quite a distance from them, avoiding manure piles or keeping them screened away from flies, using well-drained and aerated range, and raising birds in screened-in brooder houses.

Treatment for tapeworm infestation is not satisfactory. Some treatments "shear" off most of the segments but leave the tapeworm heads attached. New chains of segments form and begin to pass out with the droppings in two or three weeks. Kamala and some other treatments that have been recommended in the past not only are ineffective against tapeworm removal but are harmful to the birds.

DBT (di-n-butyl tin dilaurate) and some other tin salts fed at a level of 0.5 per cent for one day are of value in eliminating tape worms.

Flukes (trematodes). Fluke worms are not common parasites of poultry at the present time. In recent years they have been found in the skin, proventriculus, cloaca, and oviduct of chickens in some of the North Central states. Birds having access to swamps may become infested.

Symptoms of fluke worm infestation of the cloaca and oviduct are dullness, loss of weight, paleness, and decreased egg production.

The skin fluke impairs the health of the fowl and produces cysts in the skin in the abdominal region and around the vent. The cysts are smooth and shiny, grayish-white in color, and vary from two to ten millimeters in diameter. Most of them show a small black pore through which eggs pass.

Autopsy of fowls infested with fluke worms may show peritonitis and collapsed ovules containing grayish-yellow material mixed with fibrin and pus. The proventriculus may be enlarged and inflamed.

Close examination of the affected tissues reveals the presence of small, flat, unsegmented, leaflike, reddish worms one-sixth to one-fourth inch long.

Since fluke worms infest the oviduct and cloaca, they may be found occasionally in eggs.

The *life history* of the oviduct fluke involves snails and dragonflies. It has been found in crows and English sparrows and may be spread by them.

Control of fluke worm infestation may be accomplished by keeping chickens fenced away from ponds, swamps, and other wet places, and thus preventing them from eating dragonflies.

English sparrows should also be kept away.

Protozoan Diseases

Protozoa are microscopic, single-celled animals. Many species occur in nature but only a few of them are pathogenic. The two most common protozoal diseases of poultry are coccidiosis and blackhead.

Coccidiosis of chickens (*Eimeria avium*). Coccidiosis is a disease of the small intestine and ceca of chickens and other birds. It is most injurious among chickens six to ten weeks old, but may affect older or younger birds.

Symptoms of coccidiosis among growing stock include droopiness, ruffled feathers, eyes closed, diarrhea, droppings streaked with blood, poor appetite, emaciation, paleness, and greatest losses six to ten days following the onset of symptoms (Fig. 9–13).

Symptoms of chronic coccidiosis among older birds include paleness, loss of appetite, ruffled feathers, droopiness, emaciation, and leg weakness or paralysis.

Autopsy findings among growing chickens infected with coccidiosis include swollen, darkened, and firm ceca; inflamed and thickened cecal walls; and contents consisting of yellowish, cheesy, blood-stained material.

Autopsy findings among older birds infected with chronic coccidiosis include thickened and inflamed intestinal wall of the small intestine in the region of the duodenal loop, grayish white spots showing on the outer intestinal surface, and a sticky mucous exudate covering the inflamed and hemorrhagic areas lining this portion of the intestine.

Microscopic examination of the scrapings from inflamed areas and the intestinal contents of birds infected with coccidiosis reveals the presence of coccidia in some stage of development. The oocysts appear as round oval bodies having a dark center, clear surrounding zone, and a double wall.

The *life cycle* of coccidiosis is direct. The oöcysts, which are the largest and most resistant stage of the organism, are passed out with the droppings from an infected fowl. Under favorable environmental conditions of warmth and moisture outside the body, the oöcysts sporulate in one to three days with the formation of sporocysts The sporulated oöcysts are infective if picked up by a susceptible bird. Development continues after ingestion with the formation of small, spindle-shaped bodies (sporozoites). The sporozoites are released from the oocyst shell and enter the epithelial cells of the intestine, where they develop into forms known as schizonts. The schizonts give rise to small sporelike forms called merozoites. The schizont to merozoite to

zont cycles are repeated several times in the intesti- wall with resultant hemorrhage and injury of the :ous membrane.

'he merozoites finally develop into male and female ns and, after union, oöcysts are again formed and sed out in the droppings. The complete life cycle ierally requires from four to ten days.

Sporulated and nonsporulated oöcysts are quite re- ant to adverse environmental conditions because of ir protective shell.

Prevention of coccidiosis losses may be accomplished immunizing the chicks at an early age. This may be ne by: (1) starting the chicks on used or compost :er where coccidia are present; (2) vaccinating the icks at three days of age by adding an inoculum of ccidia to the feed according to the manufacturer's structions; and (3) feeding a coccidiostat continu- isly at a low level to chicks on clean or coccidiosis- ntaminated litter. Some of the coccidiostats and the eventive levels recommended for continuous use in ie ration are:

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Fig. 9–11. Large tapeworms attached to the small intestine of a fowl.

Arzene (Arsenosobenzene) is available in the form f a premix for continuous feeding to chickens of all ges for resistance against cecal or intestinal coccidiosis. 'he recommended level is one pound of Arzene premix 0.002 per cent arsenosobenzene) per ton of feed.

Glycamide (4,5-Imidazoledicarboxamide) is one of he newer and less toxic drugs used for the prevention of coccidiosis. It is fed at a 0.006 per cent level. Gylca- nide is available on the market as a 12 per cent premix. t is fed at a level of one pound per ton as a coccidiosis preventative in complete broiler rations.

Nicarbazin (4,4-dinitrocarbanilide and 2-hydroxy-4,6-dimethyl pyrimi- dine) is a potent preventative of both the cecal and intestinal species of coccidiosis. It is fed at a level of 0.0125 per cent of total feed intake. It is sold as a 25 per cent premix. One pound is recommended per ton. Rations con- taining it should not be fed to other livestock or to laying hens. It may result in reduced hatchability, color loss of brown eggs, and mottling of yolks.

Bifuran, a mixture of nitrofurazone and furazolidone, is recommended at a level of one pound per ton for the prevention of coccidiosis. The actual intake of the active ingredients recommended is 0.0055 per cent nitrofurazone and 0.0008 per cent furazolidone. In case of an outbreak of coccidiosis, a higher concentration of nitrofurazone is recommended in the drinking water.

Nitrofurazone soluble may be added to the drinking water as a treatment for either cecal or intestinal outbreaks of coccidiosis where preventives were not used or where outbreaks occurred in spite of their use. It is added to the

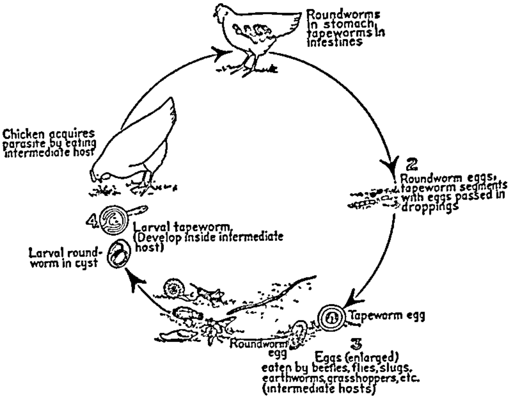

Fig. 9–12. Diagram of the various stages in an indirect life history of a tapeworm or roundworm, parasitic in poultry.

drinking water for a five day treatment period at a level of 0.3204 grams per gallon. Directions of the manufacturer should be followed in the use of this product.

Other coccidiostats, listed according to their trade names include: Nitrosal, Polystat, Sulfamethazine, Sulfa of unioxaline, Unistat and Trithiazol. Some of them are effective against more than one species for prevention, and at higher levels, for treatment. Coccidiostats require further premixing and should be used according to the directions of the manufacturers.

Treatment for coccidiosis involves the intermittent use of coccidiostats at higher levels than used for prevention. Directions of manufacturers should be followed closely. Using higher levels and for a longer time than recommended or improper mixing may result in stunted growth or mortality because of the toxic nature of the products.

Coccidiosis of turkeys. There are several species of coccidia found in turkeys. Three of them may cause losses. Coccidiosis usually affects poults two to ten weeks of age, although outbreaks may occur in older flocks.

Symptoms of coccidiosis include a sudden drop in feed consumption, a rapid loss of weight and a nonbloody diarrhea. The droppings are loose to watery and contain a slimy mucous.

Autopsy reveals a red, inflamed, swollen intestine filled with a greenish-white mucus.

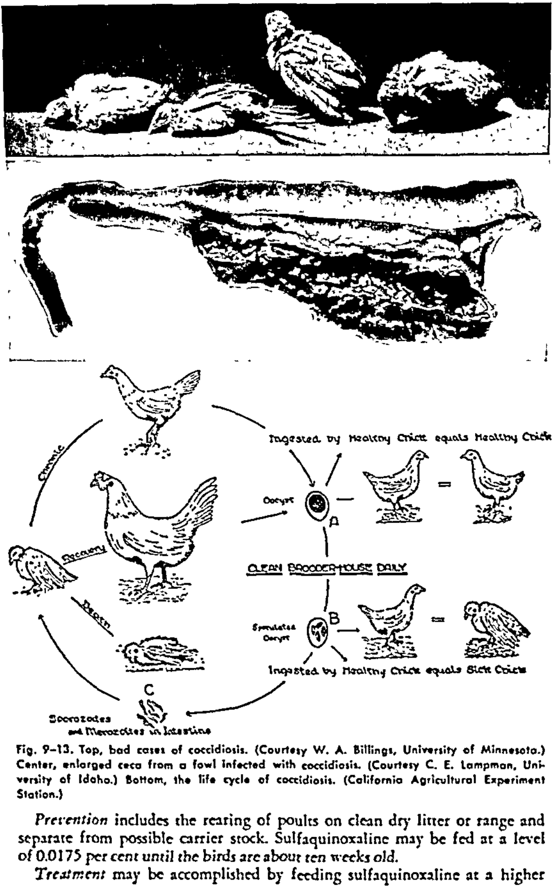

Fig. 9-13. Top, bad cases of coccidiosis. (Courtesy W. A. Billings, University of Minnesota.) Center, enlarged ceca from a fowl infected with coccidiosis. (Courtesy C. E. Lampman, University of Idaho.) Bottom, the life cycle of coccidiosis. (California Agricultural Experiment Station.)

Prevention includes the rearing of poults on clean dry litter or range and separate from possible carrier stock. Sulfaquinoxaline may be fed at a level of 0.0175 *per cent until the birds are about ten weeks old.*

Treatment may be accomplished by feeding sulfaquinoxaline at a higher

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Fig. 9–14. The liver of a turkey which died of blackhead.

level (0.05 per cent) and intermittently (feed for two days, skip three days, feed again for two days and then place back on regular feed).

Blackhead (***Histomonas meleagridis***). This protozoan disease also known as histomoniasis and infectious enterohepatitis, may cause heavy losses in turkeys of all ages and also in chickens if resistance has been lowered by vaccination or other causes.

Symptoms include droopiness, sulfur-colored droopings, and a darkened head (blackhead) Autopsy reveals inflamed and ulcerated ceca, resembling coccidiosis in chickens (Fig. 9–13), round grayish-white lesions producing sunken areas (Fig. 9–14), and peritonitis.

The birds may become infected by picking up the parasite from infected or carrier birds or from contaminated feed, litter, or soil (Fig. 9–15). The protozoan may also be carried and harbored in ceca worms or their eggs (p 308). Birds picking up this worm or its eggs from contaminated sources may become infected.

Histostat (*4-nitrophenylarsonic acid*) is fed at a preventive le pounds of a 25 per cent premix per ton of feed, or 1 pound per 16 of water.

NF-180 (*Furazolidone*) is fed at a preventive level of 1 to 2 p a premix (50 grams per pound) per ton of feed. In case of an outl crease the level to 3 pounds per ton for a week.

Other histomonostats are available. Some of them, like most of tl are effective against other protozoan diseases such as coccidiosis and tiasis and at higher levels are somewhat effective for treatment in ca breaks. The blackhead preventives and treatment drugs should according to the directions of the manufacturer.

Hexamitiasis is an acute or rapidly developing and fast spreadir *causing inflammation of the intestine* (*catarrhal enteritis*) *in tu* several species of semidomesticated birds. Affected birds are listl with drooping wings, and produce foamy droppings. Losses may *20 to 90 per cent among three to five month-old turkeys.*

The skin is dry and the flesh is dehydrated. The liver, and some kidneys, are congested. A catarrhal condition of the small intesti chief pathological condition. The surface may be coated with a thic or a thin watery foam.

The protozoan parasite may be picked up from carrier birds thr litter, water, or soil contaminated with droppings from carrier bir

In case of an outbreak, isolate the sick birds, move the others 1 to clean range, and use an antibiotic (chlortetracycline) in the water (1 gram to 5 gallons) or in the feed at a level of 200 gram for two or three days and repeat if necessary. Furazolidone (p. 3 also be used in the drinking water or feed to help control losses fi mitiasis. Nithiazide may be used as for blackhead (p. 317).

Trichomoniasis. This is a protozoal disease that has been observ growing chickens and turkeys.

Symptoms of trichomoniasis infection include paleness, droopi odor, and subnormal temperature.

Autopsy examination reveals a chronic ulceration of the crop sionally the gullet and proventriculus. Rough, protruding, yellowi like projections are firmly imbedded in the mucosa and may partly lumen.

Control of trichomoniasis infection is accomplished by keepin stock on range away from dirty wet places and moldy or decompose

In case of an outbreak, change the range and give milk to dri copper sulphate to the drinking water (one part in two thousand).

Spirochetosis. This disease or one similar to it has been observ chickens in some of the southern states. It is transmitted by ticks.

Symptoms of spirochetosis include drowsiness, paleness, loss o ruffled feathers, diarrhea, weakness, prostration, paralysis, and de three to fifteen days.

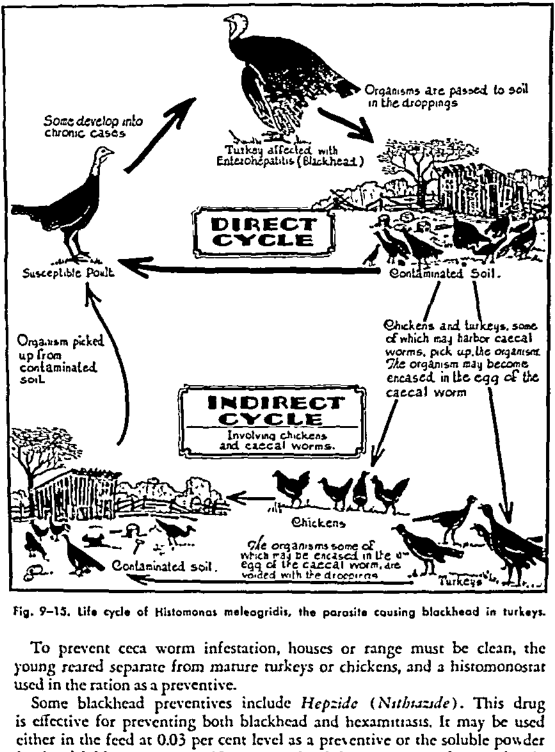

Fig. 9–15. Life cycle of Histomonas meleagridis, the parasite causing blackhead in turkeys.

To prevent ceca worm infestation, houses or range must be clean, the young reared separate from mature turkeys or chickens, and a histomonostat used in the ration as a preventive.

Some blackhead preventives include *Hepzide* (*Nithiazide*). This drug is effective for preventing both blackhead and hexamitiasis. It may be used either in the feed at 0.03 per cent level as a preventive or the soluble powder in the drinking water at 0.02 per cent level for treatment of an outbreak. Treatment should be used for seven to ten days.

Enheptin A (*2-acetylamino-5-nitrothiazole*) is used as preventive for blackhead at a level of 2 pounds of a 15 per cent premix per ton of feed. In case of an outbreak, feed at a level of 6.6 pounds for two weeks and then reduce to the preventive level.

Symptoms of thrush infection include poor appetite, weakness, emaciation, and a slimy mucous material in the mouth.

Autopsy examination of birds affected with thrush reveals the presence of grayish-white or yellowish patches on the mucous membrane of the mouth, whitish ulcers in the crop, brownish or mucoid deposits in the glandular stomach, and ulcers in the gizzard. The lesions may be so small in young chicks that they may be overlooked.

Microscopic examination of the lesions reveals the presence of the yeast-like fungus, *Monilia albicans* or *Oidium*.

Control of thrush infection consists of the prevention of healthy birds from eating contaminated feed or litter and drinking from contaminated vessels.

The fungus may be spread by way of the feeders, drinking vessels, litter, and possibly by eggshells. The period of incubation is about a month.

In case of an outbreak, use one part copper sulphate in 2000 parts water as the drink for a few days, dispose of sick birds, and clean and disinfect the premises.

Favus. Favus is a rather uncommon fungus disease of the unfeathered part of the head, particularly the comb.

Symptoms of favus infection include yellowish-white scaly lesions on the surface of the skin of the head, and, in bad cases, loss of feathers or broken ones on the neck and body.

Control of favus infection is most easily attained by disposal of all infected birds. Since the disease may be transmitted to man, one should use care in handling affected birds in order to avoid the introduction of the organism into cuts or scratches.

Favus infection may be cured by one or more applications of an ointment of formaldehyde and vaseline (one part formalin in twenty parts of vaseline).

Bacterial Diseases

Bacteria are widely distributed in nature. Most of them are beneficial to man and animals. A few are pathogenic. The principal bacterial diseases of poultry are pullorum, fowl typhoid, cholera, and tuberculosis.

Pullorum. Pullorum is a common and widespread disease which may affect poultry of all ages. It is the most frequent cause of mortality in the first three weeks after hatching. Pullorum may also cause economic losses by reduced egg production and hatchability, and mortality of mature birds (Fig. 9–16).

Symptoms. One of the chief symptoms of pullorum infection among chicks is high mortality in the first three weeks after hatching, with the peak about the tenth day. Chicks may die suddenly without apparent symptoms. In most cases, however, they huddle under the hover with closed eyes and drooping wings. Their droppings may be whitish, foamy, and sticky, or sometimes brownish in color. The material may stick to the down in the region of the vent, resulting in the condition known as "pasting up behind." Chilling or

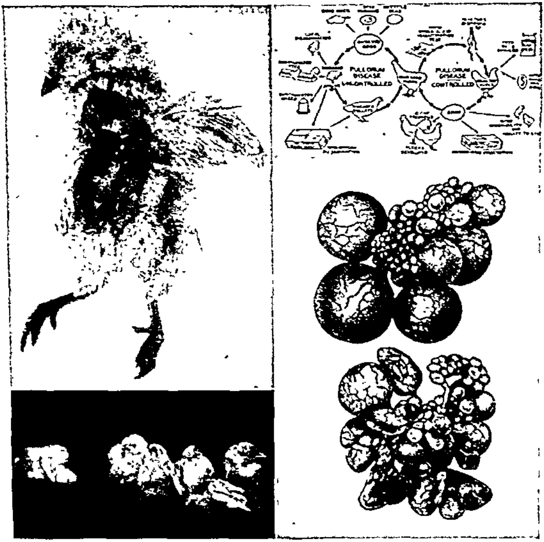

Fig. 9–16. Pullorum disease. Left—upper, chicks infected with pullorum disease in the incubator may show necrotic spots in the lungs. (Courtesy L. P. Doyle, Purdue University.) Left—lower, appearance of chicks infected with pullorum disease. (Courtesy L. P. Doyle, Purdue University.) Right—upper, graphic illustration of pullorum control. (U. S. D. A. Farmers' Bulletin 1652.) Right—lower, normal ovary above and an ovary from a bird with pullorum disease below. (After Rettger.)

overheating of chicks causes a diarrhea very similar to that produced by pullorum.

Mature birds *generally show no outward symptoms, since the disease is* usually localized in the ovaries. Some of the diseased hens lay at a low rate or quit laying entirely, while others become thin and weak and show signs of diarrhea.

Autopsy examination. Pullorum-infected chicks that die during the first four or five days often fail to show any lesions. Those dying after this time may show firm, whitish spots in the lungs. This is often the case when chicks become infected in the incubator by inhaling down or dust which carries the germs. The lung lesions may be confused with those caused by brooder

pneumonia or mold infection. Abscesses may be found in the wall of the gizzard, in the liver, and in the heart muscles. A white stringy material may cover the heart. While all of these changes are typical of pullorum in the chick, the only sure diagnosis is to find the organism (*Salmonella pullorum*). It is found most often by making bacterial cultures from the heart blood, liver, lung lesions, and unabsorbed yolk.

Hens usually show lesions in the ovaries. Some of the yolks are angular, shrunken, hard, and brownish or greenish in color. Pullorum infection in the ovary may be confused with ovarian tumors. Definite diagnosis depends on isolation of the pullorum organism from the ovary by bacterial culture. The bacteria may localize in other parts of the body. Pullorum infection may cause discolored testes in males and inflammation of the heart muscles of males and females.

Control. Pullorum disease may be controlled by removing birds which have the disease from the breeding flock and selling them for meat. Carriers of pullorium disease may be detected by a blood test. There are two practical tests in use.

The *whole blood test* involves a drop of blood from the bird and a drop of stained pullorum antigen. A drop of antigen is placed on a test plate; a drop of blood obtained with a wire loop from a pricked wing vein is added and the mixture stirred with the loop. If the bird has the disease, flakes appear in the mixture within a minute (Fig. 9–17). If the bird does not have the disease, no flakes appear in the mixture.

The *standard tube test* involves the use of definite amounts of blood serum and a pullorum antigen. A few cubic centimeters of blood are collected in a vial by puncturing the brachial vein. After the blood has clotted, a definite amount of serum (usually .04 or .08 cc.) is removed and added to an agglutination tube. Two cubic centimeters of pullorum antigen (a suspension of dead pullorum bacteria) are added to the agglutination tube, the mixture shaken, and incubated over night. If the bird has the disease, the bacteria are agglutinated and settle to the bottom, leaving a clear liquid in the tube. If the bird does not have the disease, the suspension in the tube remains turbid.

The whole blood test is gaining in popularity because it involves less labor and necessitates only one handling of the birds.

Sanitation in the incubator is a further means of controlling the spread of pullorum disease. Increasing the humidity in the incubator to 90 to 95° F. wet bulb reading during the hatch will help to keep dust and down from flying in the machine.

Thorough cleaning of the incubator between hatches will also lessen the chances of spreading pullorum by means of dust and down.

Fumigation of the incubator with formalin between hatches is a good means of killing pullorum bacteria and other microorganisms that may be present in the machine or on the eggshells.

The use of sanitary feeders and waterers help reduce the spread of the disease.

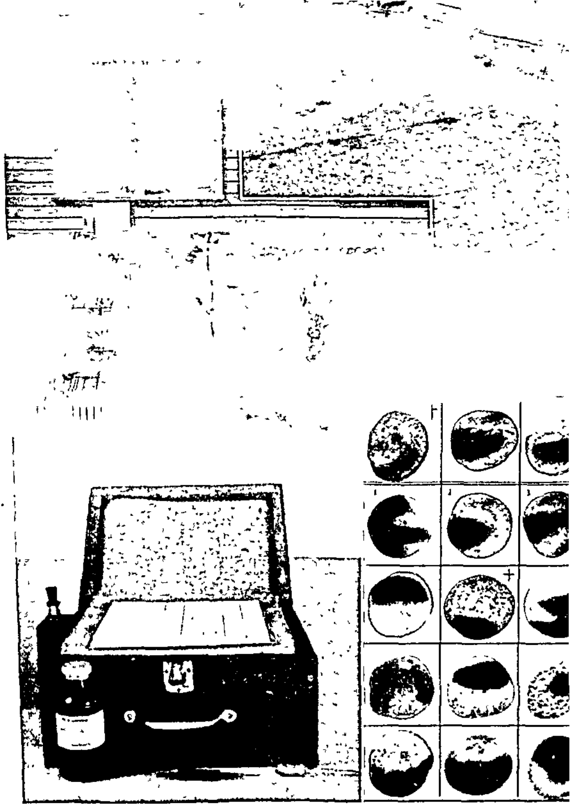

Fig. 9–17. The whole blood pullorum test. Upper left, a general view of a set-up for testing. (U. S. D. A.) Upper right, a table for holding birds. Lower left, a testing cabinet containing a can of hot water and holder for the antigen bottle; test plate or paper; stock bottle of antigen; loop and needle holder; and antigen dropper. Lower right, a section of a test paper showing positive (+) and negative reactions. (Courtesy Columbus Vaccine Company.)

Treatment of an infected group of chicks with a sulfa drug or nitrofurazolidone (p. 313) will reduce the mortality.

Fowl typhoid. This is an infectious septicemic disease of chickens and other domestic birds. It is most common among mature birds but may also affect young stock.

Symptoms of birds infected with fowl typhoid are drowsiness, ruffled feathers (Fig. 9–18), paleness, and yellowish or greenish diarrhea. The course of the infection in acute cases is from two to ten days. In chronic cases the birds may live for several weeks and show few visible symptoms of the disease.

Autopsy examination of birds infected with fowl typhoid reveals enlarged livers, dark in color, and often with a greenish sheen. The liver is usually dotted with tiny grayish spots and has a tendency to break easily. The spleen and kidneys are usually enlarged. The heart may be pale and have grayish, firm nodules of varying size in the heart wall. The blood is thin, pale red, and does not clot easily. The lining of the intestine is pale or may show a slight inflammation. The intestinal contents are usually slimy and yellowish.

Definite diagnosis depends on isolation of the causative organism of fowl typhoid (*Salmonella gallinarum*) by bacteriological culture methods, from the tissues of the body.

Spread of fowl typhoid is by way of the droppings from infected to healthy chicks. It may be spread from one bird to another by contaminated soil, litter, feed, or water. It may be introduced into the flock by infected fowls, wild birds, or on the feet of animals or people.

Control of fowl typhoid consists in the removal of all infected or suspicious birds as soon as symptoms of ill health are noticed; use of clean, sanitary feeders and waterers; frequent change of litter and the use of a liberal amount of it; and keeping birds away from contaminated yards and range. In other words, use every means possible to keep healthy chickens from coming in contact with the droppings from infected birds.

In case of a fowl typhoid epidemic in a community, it is advisable to vaccinate the flock as a preventive measure (Fig. 9–18). One to two cubic centimeters (depending on size of bird) of a fowl-typhoid bacterin may be used.

The pullorum test used for detecting carriers of pullorum also detects carriers of fowl typhoid. This is true because the organisms causing the two diseases are much alike and produce cross agglutination.

Carriers of other *Salmonella* infections, such as aertrycke and paratyphi, may also be detected by the pullorum test, as these infections are somewhat similar to pullorum.

Salmonella gallinarum, are injected beneath the skin. In case of an outbreak of typhoid disease, feed nitrofurazolidone (NF-180) at a level of 2 pounds of premix (50 grams per pound) per ton for two weeks and then a pound per ton for an additional two weeks.

Birds vaccinated against fowl typhoid infection should not be tested for pullorum infection for at least three weeks after the vaccination.

Fig. 9–18. Fowl typhoid. Above, symptoms include drowsiness, pale or darkened comb, and drooping wings. Below, technique for preventive vaccination.

Fowl cholera. Fowl cholera is a highly infectious septicemic disease of all domestic birds. It may affect birds of all ages and appear in acute or chronic form.

Symptoms of fowl cholera vary with the severity of infection. In acute outbreaks, finding some dead birds on the roosts or in the nests may be the first indication of infection. These birds may have appeared perfectly healthy only

a short time before. In the less acute forms, the first symptom is yellowish coloration of the droppings. This is followed by yellowish, brownish, or greenish diarrhea. The comb turns a bluish-red, the body temperature increases, and there is loss of appetite and increased thirst. The bird becomes drowsy and sleeps a great deal of the time with the head drawn down to the body or tucked backward and resting on the feathers about the wing. Respiration is difficult and at times an accumulation of mucus in the mouth and air passages may cause a rattling noise as the bird breathes.

The chronic form of fowl cholera infection is indicated by paleness, emaciation, and a lack of activity. Lameness may be present in prolonged cases as a result of joint infection by the germs. In some cases the birds have "colds" accompanied by gasping and swelling of the head and wattles. When first swollen, the wattles are soft and warm; later they become hard and cold.

Cholera may destroy a large number of birds in the flock in a few days and then disappear, or may remain in chronic form for months, only occasionally killing a bird.

Autopsy examination of birds infected with cholera may show sticky mucus in the mouth and air passages, reddish discoloration of the skin and breast muscles, a congested and darker than normal color of internal organs, light- or dark-colored liver covered with small white foci, swollen spleen, and red spots. Birds that have recovered from the disease may be carriers.

Control of fowl cholera is accomplished by killing and burning any birds that have the acute feverish symptoms. Remove the litter frequently. Use clean, sanitary feeders and waterers. Avoid the use of contaminated yards or range. Keep flies and wild birds away from the premises in so far as possible. Infected flocks recover with less mortality if kept in warm, sanitary, and uncrowded houses.

Infected wattles may be removed by surgical amputation.

Treatment consists of the use of a sulfa drug or furazolidone (NF-180) in the feed or drinking water according to directions of the manufacturer. Water treatment is preferable because sick birds are more likely to drink than eat.

Sodium sulfamethazine may be used in the drinking water at 0.1 per cent level or sulfamethazine powder in the feed at 0.5 per cent level for two days and repeated twice at four-day intervals.

Sodium sulfaquinoxaline may be used in the drinking water at 0.025 per cent level or in the feed at 0.05 per cent level, intermittently, as directed for sulfamethazine.

Fowl tuberculosis. Avian tuberculosis is a chronic infectious disease of poultry and wild birds. It is most commonly observed in birds more than a year old.

Symptoms of fowl tuberculosis include paleness, weakness, emaciation, loss of muscle meat from the breastbone, lameness, diarrhea, complete exhaustion, or hemorrhages on the surface of the heart, inflamed duodenum with hemorrhages of the inner lining, congested blood vessels supplying the visceral organs, congestion and small hemorrhages in the lungs, and yellow cheesy de-

posits in various parts of the body (Fig. 9–20).

In chronic cholera cases there may be pus in the lungs and air sacs; soft, flabby, and irregular ova; and rupture of ova in the body cavity.

Positive diagnosis depends on finding the *Pasteurella avicida* bacteria in the heart blood or organs of the body.

Spread of fowl cholera is by way of the droppings from infected to healthy birds. It may be carried by wild birds and insects and on the feet of animals. *In a few instances the disease may be* well established in birds that appear to be in good condition.

Autopsy examination reveals characteristic grayish-white or yellowish tumors of varying sizes in the liver, spleen, and intestines (Fig. 9–20). These tubercles when cut open show a solid, grayish, or glistening interior. Those in advanced stages of development show yellowish, cheesy, or crumbly masses in their interior.

Positive diagnosis depends on finding *Mycobacterium tuberculosus avium* in the lesions.

Fig. 9–19. Hemorrhages and red spots may be found on the hearts of chickens that die of cholera. (Illinois Station Circular 441.)

Spread of avian tuberculosis infection is by way of contaminated water, feed, litter, or soil. It may be carried from flock to flock by infected fowls, wild birds, rabbits, rats, mice, and equipment. Swine are susceptible to avian tuberculosis and cattle may become infected from swine.

Control of avian tuberculosis is accomplished most satisfactorily by disposal of the entire flock. The birds in good condition may be sold for meat purposes and the thin ones should be killed and burned.

The old birds may be disposed of in the spring and the building, equipment, and yard thoroughly cleaned and allowed to remain empty during the summer. Young chicks may be raised on clean range and later housed in the buildings that have been idle. *It is a good plan to dispose of all old birds at* least a month before chicks are brought on the farm.

Colds (coryza) and roup. Colds are common respiratory infections that affect poultry and wild birds of all ages. A chronic cold is also known as ocular roup. Colds cause lowered egg production.

Symptoms of coryza are watery eyes; thin serous discharge and then a

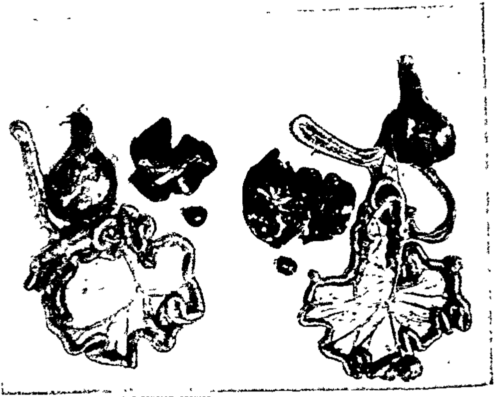

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Fig. 9–20. Lesions of the viscera indicating tuberculosis. Left, viscera of a normal bird; right, the liver, spleen, and mesentery of the small intestine show grayish, granular, tubercular lesions.

thick, sticky, foul-smelling discharge from the nostrils; sinuses filled with mucus which dries to a cheesy form, causing a swelling of the face about the eye (Fig. 9–21); and yellowish patches in the mouth.

Autopsy examination reveals no additional characteristics.

Hemophilus gallinarum bacteria may be isolated from cultures taken from the respiratory tract. Some colds are caused by a virus.

Control of colds and roup may be accomplished by removing all sick birds as soon as symptoms are observed, feeding a good ration containing an abundance of vitamin A, eradication of external and internal parasites, prevention of drafts and sudden changes in temperature in the house, keeping the house clean and dry, and preventing overcrowding. The use of cold and roup bacterins are of doubtful value.

In case of an outbreak of colds or roup, use 0.1 per cent sodium sulfamethazine in the drinking water for three or four days. Set up a brooder stove in the house to keep the birds warm, the house dry, and to secure ventilation without drafts. The birds may be sprayed at night with one of the sprays recommended for colds or bronchitis. These sprays will not cure the trouble, but may relieve discomfort by drying up the discharge of mucus.

Individual treatment may be used if the bird is valuable enough to warrant it. Wash the nostrils and eyes with a warm solution of baking soda (one

Fig. 9–21. Chronic cold and ocular roup. Note the swollen face, exudate from the nostril, and mouth open for forced breathing. (Ohio Extension Bulletin 115.)

teaspoon in a cup of water) or salt water (one teaspoon in a quart). Irrigate the nasal passages with one of the above solutions by means of a special nasal irrigator. In case of severe swelling beneath the eye, open the spot with a sharp knife; press out the cheesy material; and wash the wound with one of the above solutions.

Botulism (limberneck). Botulism is an acute disease of poultry and wild birds characterized by weakness and prostration. The first symptoms are dullness and leg weakness. These are soon followed by paralysis of the neck, wing, and leg muscles (Fig. 9–22). The bird appears lifeless. The feathers are loose and may be plucked easily. Death may be sudden or the bird may linger for several hours.

Botulism is caused by a toxin produced by the *Clostridium botulinum* bacteria. It is a soil organism that grows out of contact with air. It may grow and produce toxin in dead animals, closely packed hay, and in canned foods not thoroughly cooked.

In case of an outbreak, shut the birds off the range until the source of the trouble has been located and removed. Give the birds a laxative as in case of

Fig. 9–22. Limberneck or botulism. (Ohio Extension Bulletin 115.)

poisoning. Do not feed spoiled canned food to chickens unless it has been thoroughly cooked to destroy the toxin.

Navel infection (omphalitis). Navel infection is also known as "mushy chick disease" among hatcherymen. It is a rather uncommon disease that occurs among chicks the first day or so after hatching.

Symptoms of navel infection among chicks are drowsiness, mushy and puffed appearance of the abdomen, death within a few hours after the first symptoms, and high mortality the first seventy-two hours after hatching.

Autopsy examination of birds having navel infection shows a parboiled red color of the abdominal skin and muscles, accumulation of water and gas in the abdominal cavity, pale and swollen liver and kidneys, and fluid, putrid contents of the yolk sac.

Several kinds of bacteria have been isolated from cases of navel infection. The causative organism has not been definitely established.

Control of navel infection may be accomplished by the use of strict sanitation in incubators. Incubators should be thoroughly cleaned and fumigated between hatches (p. 145).

In case of an outbreak, fumigate the incubators between hatches with three times the strength of formalin used at hatching time. It may also be necessary to clean, disinfect, and fumigate the egg, incubator, and battery rooms to destroy the disease germs in the chick hatchery.

Apoplectiform septicemia. This is a rapidly fatal bacterial disease which may affect chickens, turkeys, pigeons, and other fowls.

Symptoms include sudden death or depression, listlessness, staggering gait, prostration, and finally death.

Autopsy examination of infected birds shows discoloration of the skin of the breast and neck caused by subcutaneous hemorrhages; serous or bloody exudates in the heart sac and body cavity; swollen liver, spleen, and kidneys; and congested intestines and lungs.

Bacterial cultures from the blood reveal the presence of *Streptococcus capsulatus gallinarum.*

Control of apoplectiform septicemia infection involves the use of the same sanitary measures as used for the control of cholera and fowl typhoid.

Healthy fowls may be vaccinated against apoplectiform septicemia by the intravenous injection of a killed culture of the causative organism.

Erysipelas. This turkey disease is caused by the same bacterium (Erysipelothrix rhusiopathiae) which causes erysipelas in swine and sheep. It may also be spread to man by handling infected turkeys or farm animals. The disease may affect turkeys of all ages. It may be chronic or acute, resulting in as

high as 30 per cent mortality. The organism gains entrance most readily through a break in the skin. It may live throughout a winter in contaminated soil or litter.

Symptoms of erysipelas include swelling and red discoloration of the snood or caruncles (Fig. 9–23), inactivity, poor feed consumption, thick mucus in the nostrils, and a yellowish-green diarrhea.

Autopsy findings include scattered hemorrhagic areas throughout the muscles, enlarged congested liver and spleen, and inflamed intestines filled with a blood-tinged mucus.

Control involves isolation of sick birds and removal of flock to clean range or litter. Sick birds should be injected in the breast or thigh muscles with 100,000 units of procaine penicillin. It may be repeated in 24 to 48 hours.

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Fig. 9–23. Erysipelas symptoms showing a swollen snood.

Preventive vaccination may be used by injecting 1 to 2 cc. of ersipelas bacterin subcutaneously under the skin in the neck region.

Virus Diseases

Viruses are believed to be living organisms, so small that they are difficult or impossible to see with the microscope. The proof of their existence is the ability to produce disease by introducing body tissue, or fluid which contains them. All infectious diseases, where a causative organism has not been isolated, are generally classed as virus diseases. The principal poultry virus diseases are fowl pox, infectious bronchitis, Newcastle disease, and lymphomatosis.

Fowl pox. Fowl pox has also been called chicken pox, contagious epithelioma, canker, avian diphtheria, and sore head. It is a highly infectious disease affecting the head and mouth of chickens, turkeys, other poultry, and wild birds.

Fowl pox usually occurs in the fall and winter, but may occur at any time. It generally affects birds during the first year of production, but may affect younger or older birds. Fowl pox slows up and may stop production. The losses may vary all the way from few or no deaths to rather high mortality.

Symptoms of fowl pox are watery eyes and a discharge from the nostrils, as in the case of colds; and small, grayish, raised blister-like spots that appear on the comb, face, and wattles and are followed by a drying and darkening of the lesions to form warty-like scabs (Fig. 9–24).

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Fig. 9–24. Fowl pox and its control. Above, the dark nodules or scabs are fowl pox lesions. Below, wing vaccination by the stab method for prevention of fowl pox.

The severity of the disease depends on the extent of diptheric deposits in the mouth. These are first thin, whitish, or yellowish in color, and then become thicker, firmer, and harder to remove.

The period between exposure to fowl pox and the appearance of the first symptoms of the disease varies from three to fifteen days. The duration of the disease varies from two or three days to as many weeks in acute cases and may last in a flock in chronic form for several months.

The fowl pox virus gains entrance to the body through a break in the skin.

Spread of fowl pox is by contaminated material and by close contact. The disease may be carried from farm to farm by fowls that have had the disease or have been vaccinated recently, by mosquitoes and other biting insects, by wild birds, and by equipment.

Control of fowl pox is accomplished by using preventive measures. There is no satisfactory treatment. If the disease is present in the flock in chronic form or if it has caused trouble during the past two or three years, it is advisable to vaccinate all birds that have not had the disease.

In case of an outbreak of pox among birds that are already in production, the flock should be vaccinated with the pigeon strain of fowl pox vaccine. Its action is milder than that of the fowl strain and does not cause so great a loss in egg production.

In preventive vaccination in pullet flocks, the birds should be vaccinated with a fowl strain of pox vaccine when the birds are eight to twelve weeks old (Table 9–8). Later, vaccination gives the birds a "set back" in development.

Table 9–8

SUGGESTED VACCINATION SCHEDULE FOR VIRUS DISEASES

Age	Vaccination	Method *
1–7 days	Newcastle and bronchites (mixed)	*Drop in nose or eye or drinking water*
4 weeks	Newcastle revaccination	Drinking water, spray or dust
6 weeks	Laryngotracheitis if disease is prevalent in territory	Brushed on inner wall of cloaca or dropped in vent
8 to 12 weeks	Fowl pox **	Wing stab
16	Newcastle and bronchitis revaccination	Drinking water, spray or dust
First Annual Molt	Newcastle and bronchitis revaccination	Drinking water, spray or dust

* Follow the directions of the manufacturer of the vaccine used.
** May be vaccinated at any later age with pigeon pox vaccine, but duration of immunity is not as great.

While the fowl strain of pox vaccine is more severe in its action than the pigeon strain, it is believed to provide more lasting immunity.

Vaccination for prevention of fowl pox is carried out by making a break in the skin and introducing a little of the vaccine mixture. In the feather follicle method, three or four leg feathers are plucked and the vaccine added to the spot with a brush. In the more recent stab method, two sewing ma-

chine needles are pushed through a cork with the points about one-fourth inch apart. The wing is stretched out and the web is pierced from the underside, thus making four vaccination points through the double layer of skin simultaneously. The eyes of the needles take up sufficient vaccine to make the single stab effective.

The reaction denoting a "take" may be observed in five to seven days. The site of vaccination will show inflammation and later the formation of a scab which will drop off in three or four weeks.

Laryngotracheitis. This disease is also known as infectious tracheitis, influenza, or flu. It is a highly infectious respiratory disease of chickens, but may also affect turkeys, ducks, pheasants, and wild birds. Laryngotracheitis is more prevalent, lasts longer, and causes greater mortality among birds six months to one year old than among older or younger birds. It occurs most frequently during the fall and winter months.

Symptoms of laryngotracheitis are watery eyes, lack of activity, coughing, sneezing, shaking the head, gasping for breath (Fig. 9–25), coughing up of bloody mucus, strangulation, and possibly sudden death.

The disease may go through the flock in one to two weeks or it may continue for a month or more.

Autopsy examination of birds infected with laryngotracheitis reveals an *inflamed glottis and trachea,* presence of yellow cheesy material, and the nostrils and mouth filled with a sticky mucoid exudate.

In case of an outbreak, use the same measures as for colds (p. 328). Inhalants will check the discharge of mucus in the respiratory passages. If the mucous discharge can be checked, fewer birds will die as a result of strangulation.

Cloacal vaccination (Table 9–8) is used for the prevention of laryngotracheitis in a flock and for preventing the spread from infected birds to healthy ones in case of an outbreak. The bird is held by an assistant and the upper part of the vent is rolled open with the thumb and forefinger. A stiff brush moistened with vaccine is rubbed back and forth across the mucous membrane until a slight redness is produced. Or, one type of vaccine may be dropped in the vent.

Five days after vaccination a "take" is indicated by a reddened and swollen membrane at the point of vaccination, which is also covered with mucus.

Infectious bronchitis. This is a highly infectious disease which may occur in birds of all ages. It lasts about two weeks. In young chickens, three or four days to three or four weeks, mortality may range from near 0 to 90 per cent. It results in decreased growth rate and lower carcass quality. In the laying flock, infectious bronchitis results in a sudden drop in egg production but does not cause high mortality. When egg production starts to increase again, the eggs are often irregular in shape, have a very poor shell texture and damaged interior quality.

Symptoms of infectious bronchitis include gasping, a crackling sound when held close to the ear, a nasal discharge and decreased appetite.

Autopsy reveals a thick mucus or plugs of exudate in the bronchi of

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Fig. 9–25. Laryngotracheitis. Above, typical symptoms. Below, cloacal vaccination for prevention.

infected chicks. A fibrinous material may be found in the heart sac and the air sacs are cloudy or contain a little or much cheesy material.

Control of infectious bronchitis is by prevention with strict isolation or preventative vaccination (Table 9–8). The vaccine may be used as a dust, spray or in the drinking water. The immunity lasts for only a few months. Directions of the vaccine manufacturer should be followed closely.

Chronic respiratory disease (C R D). This disease may affect broilers, replacement pullets, and laying and breeding chickens. It is usually chronic in nature, resulting in low mortality and decreased growth rate, larger than normal percentage of cull birds, reduced egg production, and poor feed conversion. The causative organism is believed to be either a small pleuropneumonia bacterium of the type which causes infectious sinusitis in turkeys (p. 337), or a virus. It appears to be an infective agent of low virulence which may be present in the respiratory tract and causes infection when the resistance of the bird is reduced or stress increased as a result of other respiratory diseases, vaccination, or unfavorable environment. The causative organism may be carried in the eggs of infected breeding flocks. Air-borne infection and contact transmission are likely.

Symptoms of C R D include nasal discharge, respiratory rales, a hacking cough, reduced feed intake, decline in egg production, and weight loss (Table 9–9). Symptoms in mature birds resemble those resulting from infectious bronchitis (p. 334) or Newcastle (p. 340) disease. Mature birds seem to develop the disease more readily than young and are believed to be more susceptible.

Autopsy usually reveals a marked thickening of the air sac membranes and accumulation of caseous pus in the air sac cavities. A similar condition is observed in turkeys infected with infectious sinusitus. It is less common in chickens with infectious bronchitis or Newcastle disease. Autopsy may also show a fibropurulent exudate coating the liver and a fibrinous pericarditis.

Tracheal culture and blood tests may be made to differentiate C R D from other respiratory diseases. Hemagglutination-inhibition, whole blood, serum plate, and tube agglutination blood tests may be used to establish the presence of the disease in a flock. Results of blood tests usually agree on a flock basis but not on individual birds.

Control of C R D may be accomplished by sanitary farm conditions, avoidance of stress factors and avoidance of the introduction of stock or hatching eggs from infected flocks. A blood test may be used to detect the presence of the disease. Once it is present in a breeding flock, all the birds should be sold. The premises should be cleaned before new stock is introduced.

In case of infected valuable breeding stock, the life cycle of the PPLO organism may be broken by injecting each breeder with dihydrostreptomycin, an antibiotic. Eggs produced the following two weeks are believed to be free from PPLO. Feeding infected flocks a high level (100 grams per ton) of antibiotic results in reduced mortality, better growth or egg production, and improved feed efficiency. Magnamycin, terramycin, streptomycin, and aureomycin appear to be most effective.

Table 9–9

AIDS FOR DIAGNOSIS OF VIRUS RESPIRATORY DISEASES

Disease	Rate of Spread	Age Affected	Duration	Mortality	Symptoms	Autopsy
Infectious bronchitis	Rapid	All ages	4–21 days	0–40%	Coughing, sneezing, rattle. Sudden drop in egg production.	Cheesy material in bronchial and air sacs.
Newcastle disease	Rapid	All ages	4–28 days	0–100%	Breathing difficulty. Nervous disorder. Sudden and complete drop in egg production.	Mucous in trachea. Cloudy air sacs.
Chronic respiratory disease (CRD)	Slow	All ages	Months	0–40%	Respiratory symptoms. Poor feed. Consumption. Emaciation.	Yellowish false membrane over viscera and in air sacs.
Infectious laryngotra-cheitis	Rapid	Young adults. Adults	521 days	5–60%	Coughing of bloody mucus.	Bloody mucus in trachea.
Infectious cold (coryza)	Rapid	Young adults. Adults	10 days to months	0–25%	Nasal dis-charge. Swelling of face.	Mucus in upper respiratory passages.

Infectious sinusitis. This is a contagious, chronic respiratory infection of turkeys caused by a pleuro-pneumonia-like (PPLO) organism, which has some of the properties of both a small bacterium and a virus. The causative organism is believed to be similar to the one which causes C R D in chickens (p. 336). Infectious sinusitis may be spread by nasal discharge and possibly in the eggs from infected flocks used for hatching poults.

Symptoms of infectious sinusitis include nasal discharge, foamy secretion in the eyes, and eventual swelling of the sinuses with a gelatin-like exudate (Fig. 9–26). Feed consumption declines and there is often a loss in weight.

Autopsy may reveal congestion of the lungs, and air sacs as in C R D in chickens (p. 336).

Treatment involves isolation of sick birds as soon as detected. They may be given individual injection of an antibiotic preparation directly into the affected sinus or intramuscularly. Streptomycin, aureomycin, chloromycetin


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Fig. 9–26. A severe case of sinusitus.

and others may be used. Directions of the manufacturers should be followed.

Lymphomatosis. Lymphomatosis is also known as range paralysis, neurolymphomatosis, and leucosis. The disease here described is a distinct virus disease and shocld not be confused with various types of paralysis, lameness, or leg weakness resulting from vitamin deficiencies, parasite infestations, or bacterial infections. It affects chickens between the ages of six weeks and eighteen months, but the highest incidence of the disease occurs between the ages of four and twelve months. The mortality may reach as high as 75 per cent.

Symptoms. The symptoms of lymphomatosis vary with the strain of the infective agent and the course of the disease.

The *paralysis form* is first indicated by a drooping of the wing or a partial paralysis of one or both legs (Fig. 9–27). In a short time the bird is unable to stand and is not able to reach feed or water. The muscles of an affected leg often shrink or wither. Affected birds generally have a healthy appearance, except for the paralysis, and a good appetite. They may show digestive disturbances as indicated by diarrhea.

The *blindness form* is indicated by a fading of the color of the eye. It changes from the usual reddish-bay to a gray. In severe cases the pupils fail to respond to light. The eye sometimes bulges out and the bird becomes totally blind. The birds may continue to find the feed and water and lay well for a time after they lose their eyesight.

The *leucosis or leukemic form* is indicated by paleness, loss of weight, and weakness. The affected birds resemble those affected with chronic coccidiosis. The birds may live for several weeks.

The *tumor form* seldom shows any external symptoms. Lumps may be found in a few instances on almost any part of the body.

The above forms of the disease may be due to the same or different viruses. Investigators are not in agreement on this point at the present time.

Birds infected with lymphomatosis seldom, if ever, recover.

Autopsy examination. In case of lymphomatosis accompanied by paralysis, the plexuses and large nerves leading to the affected legs or wings may be enlarged and yellowish-gray instead of the normal whitish-gray color. The cross striations characteristic of normal nerves are lost, and nodules may be present anywhere along the affected nerve.

In case of the leukemic form of the disease, the liver, spleen, and kidneys are usually enlarged, grayish-red in color, and soft and flabby. The liver may be spotted with brownish or gray areas and easily ruptured.

In case of the tumor form of lymphomatosis, the masses of abnormal tissue may be found about the ovary, liver, spleen, kidneys, and other tissues of the

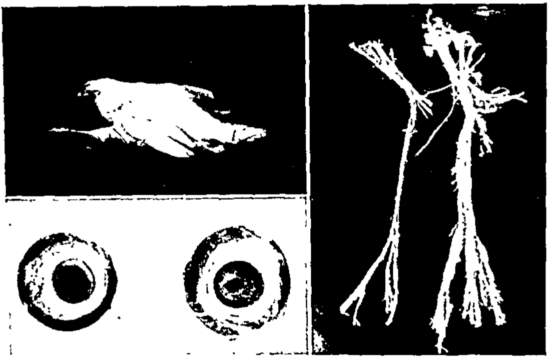

Fig. 9–27. Fowl paralysis or leucosis. (See also Figure 3–9.) Left—upper, typical symptoms of the paralysis form. Left—lower, "white eye" lesion, a symptom of leukemia. Normal eye at left and diseased eye at right. Right, leg nerves of normal fowl at left and of leucemic fowl at right. (Courtesy W. R. Graham, University of Illinois.)

body. The tumors vary greatly in size. They are generally grayish or yellowish in color. The centers of the tumors are generally necrotic and yellowish in color.

Microscopic examination of the blood generally reveals the presence of an unusually large number of white blood cells. Examination of the nerves and other tissues of the body shows infiltration of massive numbers of white blood cells.

Control. There is no known treatment for lymphomatosis. It is generally believed that chickens become infected when quite young. The development of symptoms of the disease requires a month or more after infection. Old birds are believed to be carriers of the disease. Young chicks probably become infected by contaminated feed, litter, water, or range. The disease may be carried by flies and other insects, wild birds, animals, and equipment. Young stock should be raised separate from old stock and as far away from them as possible.

Birds showing any of the symptoms of lymphomatosis should be removed from the flock as soon as noticed. Those showing only the eye symptoms of the disease may be sold for meat.

In case of an outbreak which may cause heavy losses, dispose of the entire flock. Clean and disinfect the buildings and allow them to remain idle for a month or more. Restock the farm with birds from a flock where the disease has not occurred or from one that is no longer bothered with losses from lymphomatosis.

Birds that live through an outbreak of paralysis have some immunity against the disease. Data being obtained in various parts of the country indicate that it is possible to breed strains of chickens that will have resistance against lymphomatosis infection.

Fowl plague. Fowl plague, also known as fowl pest, is a common virus disease in Europe. A few outbreaks have occurred in the United States.

Symptoms of fowl plague include ruffled plumage, loss of appetite, droopiness, darkening and swelling of the comb and wattles, and, in advanced cases, a clogging of the eyes and nostrils with a sticky exudate. Death usually occurs in from two to five days. A high percentage of the flock may die within a few days.

Control of fowl plague requires rigid sanitation. Remove, kill, and burn diseased birds. Remove the remainder of the flock to clean quarters. Thoroughly clean and disinfect buildings and equipment.

Newcastle disease. Newcastle disease, also known as avian pneumoencephalitis, is a respiratory and nerve virus infection of poultry.

Symptoms in chicks are first a respiratory infection resembling infectious bronchitis (Table 9–9). As the disease progresses, some chicks develop nervous symptoms such as distortions of the neck (Fig. 9–28), shivering, incoordination, convulsive seizures, circling, and sometimes paralysis. Mortality may be slight or it may reach 30 or 40 per cent. The nerve symptoms are somewhat like those in case of nutritional encephalomalacia (p. 295). However, autopsy reveals mucus in the trachea and clouded air sacs in Newcastle disease.

Symptoms in adult birds resemble those of a cold or infectious bronchitis. The infection spreads rapidly. There is a drop in feed consumption and a sudden drop in egg production to nearly zero in one or two days. The eggs laid during the period are generally rough-shelled or soft-shelled and the white is often of poor quality. The respiratory symptoms last from four to eight days and egg production is affected for three to eight weeks. Mortality is usually low, two per cent or less.

Control should be based on preventative vaccination (Table 9–8) rather than on treatment. Growing chickens may be vaccinated at any age, at the same time and by the same method used for infectious bronchitis. If a live attenuated vaccine is used, immunity will carry through the following laying season. Chicks hatched from immunized birds will have some immunity. However, it disappears and the chicks are susceptible to Newcastle infection by the time they are two to four weeks old. In some broiler areas where Newcastle losses have been heavy, the chicks are vaccinated when received or during the first two weeks.

If an outbreak occurs, feed a high level (100–200 grams per ton) antibiotic or NF-180 (p. 326) as directed by manufacturer.

Ornithosis. This is a virus disease of parrots and some other species of birds. It may be spread to laboratory animals and man.

In parrots the disease is characterized by weakness, prostration, diarrhea, and death. Persons contracting the disease from birds or laboratory animals develop pneumonia.

Strict sanitary measures are necessary for the prevention and control of psittacosis.

Epidemic tremors. This is a disease of chicks up to six weeks of age. It is probably caused by a virus.

Affected chicks show a constant trembling. Handling increases it. The trouble stops during sleep. Mortality may reach 50 per cent. No method of control is known.

COURTESY NORTH CAROLINA STATE COLLEGE

Fig. 9–28. Newcastle symptoms in growing chickens.

Infectious synovitis. This is an arthritic disease of growing chickens and turkeys caused by a filterable virus. The economic losses of the disease may vary from 2 to 75 per cent, resulting in emaciated birds which dress out poorly.

The disease is most common among birds 4 to 12 weeks of age but has been found in older ones. Wet, damp, and cold brooding conditions are favorable for its development.

The mortality is usually low but may be as great as 30 per cent. The affected birds become weak, listless, and tend to assume a sitting position. General lameness is evident in the flock. A greenish diarrhea is a constant symptom.

Autopsy usually reveals a creamy exudate in many joints, especially the flexor tendons of the foot pads and wing joints. In acute cases the liver is enlarged, mottled, and may contain necrotic foci.

Bacteriological examination is necessary to differentiate infectious synovitis from arthritis caused by staphylococci and from septicemic diseases such as fowl typhoid.

The disease may be prevented, checked and cleared up by high level (100 to 300 grams per ton) antibiotic feeding. Chlortetracycline and oxytetracycline use are more effective than streptomycin or penicillin. Furazolidone may be used in place of the antibiotic.

Infectious hepatitis. This disease affects both growing chickens and laying hens. It develops slowly and is accompanied by a drop in egg production of 30 to 40 per cent for a period of several days or weeks. Severely affected birds are listless and roost or stand apart from the rest of the flock. Mortality may reach 10 to 15 per cent. Autopsy reveals an abnormal liver and occasionally an abnormal heart or spleen. The liver may be enlarged, mahogany brown or pale in color, show areas of hemorrhage, possess grayish white areas of degenerative tissue, and break easily. The heart, especially of young birds, may be pale and flabby and have fluid in the pericardial sac. Liver abnormalities are more common in layers than the heart condition.

The use of 0.022 per cent furazolidone in the ration for two weeks may be used as a treatment. If the trouble reappears, repeat the treatment.

Bluecomb. This disease of unknown cause is also known as pullet disease, X-disease, cholera-like disease, contagious indigestion and monocytosis. It re-

sponds to antibiotic (p. 257) and furazolidone (p. 326) treatment like bacterial infections. There is some evidence that it is a virus disease.

Bluecomb in chickens and bluecomb in turkeys (mud fever) are probably due to different infective agents. The disease is most common among pullet chickens in late summer or early fall. It may affect turkeys of all ages.

Symptoms are usually shown by sudden loss of appetite, listlessness, diarrhea, and darkening of the head (bluecomb) and skin. There is loss in weight, dehydration of tissues, and a sharp drop in egg production. The disease usually lasts 10 to 14 days and mortality may run as high as 50 per cent, especially in young turkeys.

Autopsy. The crop may be full of sour material or empty. Hemorrhages may be seen on the heart sac and in the ovary. The pancreas is often chalky. The liver is usually normal. The kidneys and ureters are usually filled with whitish urates. There is a sticky mucous in the intestine.

Control. Avoid undue stresses on pullets at housing time. In case of an outbreak use a soluble antibiotic, as aureomycin or terramycin, or nitrofurazone (p. 326) in the drinking water, according to the directions of the manufacturer.

Diseases Associated with Egg Production

Diseases of the reproductive organs, associated with egg production, account for most of the losses of noninfectious nature among laying hens. The principal diseases associated with egg production are "pick outs," rupture of the oviduct, egg bound, ruptured yolks, and blood and meatspots in eggs. Birds may be bred for a low incidence of these troubles.

Pick outs. This trouble is usually encountered among pullets during the first weeks of egg production. If the bird, after laying an egg, does not remain on the nest or away from the other birds until the everted cloacal membrane is withdrawn, the other birds are attracted by the red membrane and begin picking it. The cloacal membrane becomes bruised and swollen and hemorrhage may result. In bad cases, the entire cloacal area is picked away and the bird dies from hemorrhage.

Injured birds should be removed as soon as noticed. Pullets should be trained to lay in nests by placing birds in them that have a habit of laying on the floor. Bright light should be excluded from the house in case "pick out" trouble is encountered.

Feeding oats, using built-up litter, and keeping legume hay or green feed available may help to prevent "pick outs." If the trouble starts and persists in spite of all of the precautionary measures, it may be necessary to trim the upper part of the beak (Fig. 9–29), especially of the offenders, back to the tender undercoating.

Prolapse of oviduct. The oviduct may come loose and protrude from the vent when a bird lays an egg. The blood which accompanies the prolapse and the oviduct itself attract other birds and the injured one is picked to death unless it is promptly isolated. The trouble is most common during the late winter or early spring and affects high-producing birds.

COURTESY OHIO AGRICULTURAL EXTENSION SERVICE

Fig. 9–29. Miscellaneous poultry troubles. Top, posture of birds with ruptured oviduct and eggs loose in the body cavity. Center: procedure for amputation of frozen combs or for dub-

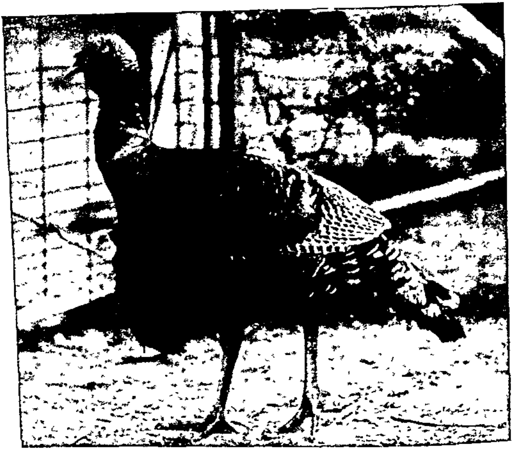

Fig. 9–30. Pendulous crop, an inherited condition.

There is no satisfactory treatment. Affected birds, observed and removed soon after the prolapse, may be used for meat.

Rupture of oviduct. Internal rupture of the oviduct may result from severe inflammation, an attempt to pass large eggs, or from injury. The breaking of the oviduct permits yolks or fully formed eggs to pass into the body cavity. The yolks may rupture and the contents dry out, forming a yellow coating over the viscera. The material interferes with the normal functioning of the abdominal organs.

Yolks or even whole eggs may get loose in the body cavity and cause a protruding abdomen (Fig. 9–29).

There is no treatment for rupture of the oviduct. The use of low perches and nests, careful handling of birds, and feeding well-balanced rations will reduce the number of cases.

Egg bound. Egg-bound trouble occurs most frequently among pullets. It results from attempts to pass large or double-yolked eggs through an oviduct that is too small for their passage. Birds appear listless and make frequent attempts to lay.

As a means of treatment, the bird may be placed on its back, a finger

greased and inserted into the oviduct, and the egg worked toward the cloaca by the finger and pressure on the abdomen.

Several eggs may collect in the oviduct, resulting in its rupture, and may cause a bird to assume the posture of a penguin.

Ruptured yolks. A yolk may rupture and flow into the body cavity or into the oviduct. When it flows into the body cavity, it covers the internal organs and gives them a yellowish cast. The accumulation of yolk material in the peritoneal cavity may result in peritonitis and death.

If the yolk ruptures in the oviduct, it adheres to the walls, causes a thickening of the membranes, and leads to a catarrhal peritonitis.

Rupture of yolks may be caused by cholera (p. 325), rough handling, fright, flying on and off of high perches and nests, and by faulty nutrition.

Ruptured blood vessels. If a small blood vessel on the follicle (p. 63) ruptures, a blood spot may appear on the yolk. If the rupture occurs in the magnum portion of the oviduct (p. 57), a blood spot may appear in the albumen of the egg. The rupture of a larger blood vessel may result in a bloody egg. Weak blood vessels in the egg forming organs (ovary and oviduct) probably stem from a weakness of these organs, permitting prolapse, ruptured yolks, egg bound, and other hereditary reproductive weaknesses.

Miscellaneous Diseases

A number of diseases of poultry are caused by injury or undesirable environment, while still others are caused by microorganisms or conditions that are not well understood. These diseases have been classed as miscellaneous. They include cannibalism, heat prostration, frozen combs and wattles, edema of the wattles, necrosis of the beak, pendulous crop, bumblefoot, vent gleet, and tumors.

Cannibalism. Cannibalism may be encountered among birds of all ages. Among chicks, the trouble is confined to toe and tail picking. Among mature birds, the vent, tail, and comb are the regions most frequently picked.

The trouble generally breaks out among overcrowded birds that are kept in close confinement. Birds picking at a wound of an injured chick or picking at the tails of birds in front of them at the feeders, may get the habit of cannibalism started. Housing pullets of different ages or stages of maturity together, birds laying eggs on the floor, and prolapse of oviduct or hemorrhage from egg laying are other things that may lead to cannibalism.

Cannibalism may be controlled by darkening the windows in the house, providing range, use of oats in the ration, and the removal of all injured birds as soon as observed. Sometimes a few birds are the cause of all the trouble. It is desirable to watch for them and remove them from the flock. At times the use of one of the above suggestions is sufficient for control of the trouble, while in other cases more than one of them need to be used.

Debeaking day-old broiler chicks for broiler production or pullets at time of housing is becoming a general practice as a sure means of preventing cannibalism. It is also used in turkey production (Fig. 6–17).

The wounds of injured birds should be painted with pine tar or an "anti-pick" compound. One such compound consists of a mixture of four ounces of vaseline, one-fourth ounce of carmine, and one-half ounce of aloes.

Heat prostration. Mature fowls are better able to withstand extremely cold than extremely hot weather. During extremely warm days, apparently healthy hens may die of heat prostration.

Helpful preventive measures against heat prostration are shade, ventilated nests, and an ample supply of water.

Frozen combs and wattles. Birds having large combs and wattles may have them frozen during extremely cold temperatures in the house. The frosted parts become swollen and painful, bluish-red in color, and the severely frozen portions slough off.

If discovered early, the affected parts may be thawed out with cold water and thoroughly greased with vaseline.

Amputation of badly frozen combs and wattles will hasten recovery (Fig. 9–29). The comb or wattle is cut off with tinners' shears or some other dull shears which crush as they cut. The crushing of the tissues and blood vessels helps to prevent hemorrhage. Searing the cut surface with a hot knife, addition of a few drops of an alcoholic solution of ferric chloride, dusting with powdered alum, or the application of a little ground mash feed to the wound will aid in stopping the bleeding which may result from the operation.

Dubbing is the term commonly used to designate the removal of the combs and wattles of growing stock to prevent freezing during the ensuing winter. The combs and wattles may be trimmed from young Leghorns by means of small sharp scissors when the birds are a day old. There is no bleeding when the operation is performed at this age.

Edema of the wattles. This disease is characterized by a hot, swollen wattle filled with a fluid which later changes to a hard cheesy nodule. Edema of the wattle is more common among males than females.

The cause of edema of the wattle is not known. The causative organism for fowl cholera (p. 325) and other bacteria have been isolated from the lesions. The trouble may start from an infection in a wound of the wattle.

The affected wattle may be removed like frozen wattles.

Necrosis of the beak. This trouble is caused by the packing of finely ground mash feed in the mouth. It may accumulate under the tongue or along the edges of the upper and lower mandibles. The accumulation of feed interferes with the closing of the mouth and results in abnormal respiration. The mouth becomes dry, inflammation sets in at the site of feed deposit, and secondary bacterial infections may result.

The trouble may be prevented by avoiding the use of finely ground mash or by using more fiber in the mash. The use of a large amount of ground wheat in the ration may cause the feed to stick in the mouth.

Affected chicks may be cured by removing the adhering food material and washing out the mouth with salt water.

Pendulous crop. Enlarged pendulous crops (Fig. 9–30) may be found

among birds of the heavy breeds of chickens and among growing poults two to three months of age.

The trouble may be caused by irregular feeding. Consumption of a large quantity of feed or water or both at a given time may cause a weakening of the crop wall which will not return to normal.

Keeping feed and water before birds of all ages at all times, preventing overheating in houses, and providing shade on range will help prevent the trouble.

Bumblefoot. Bumblefoot is a term applied to a swollen foot of a fowl. The condition, described here, is found most often among laying hens.

The ball of the foot is hot and swollen. The bird may limp and hold the affected foot up. In some cases, both feet are affected. The swollen condition is followed by an accumulation of cheesy material in the ball of the foot and between the toes.

Bacteriological examination reveals the presence of different kinds of bacteria. They probably gain entrance through a break in the skin on the foot.

In treating birds for bumblefoot, the lesions should be lanced, the cheesy material pressed or picked out, the cavity washed with salt water or 5 per cent carbolic acid solution, and the foot bandaged. The wound should be dressed daily until the bird recovers.

Vent gleet. Vent gleet is a disease of mature birds. It is characterized by a severe irritation, a watery discharge that becomes foul smelling, and a reddened area around the vent. The fowl will pick at the irritated surface, and other birds may pick at the swollen and reddened area, causing ulceration.

Affected birds should be removed from the flock, the feathers clipped around the vent, the scabs removed by washing with warm soapy water, and zinc oxide or mercurial ointment applied to the inflamed area.

Tumors. Tumors are masses of unorganized tissue which grow independently of surrounding structures and have no physiologic use. Old birds are quite likely to have tumors (Fig. 9–29). They are found most frequently in the oviduct and ovary, but may occur anywhere in the body or on the surface. They vary all the way from baglike structures filled with fluid to hard meaty or even bony tissue. Tumors may press on nerves, causing paralysis; rupture blood vessels, causing hemorrhage; close the respiratory passages, causing suffocation; and cause injury or death in many other ways.

There is no treatment for internal tumors. Some external tumors may be removed satisfactorily by surgical means.

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Chapter 10

Marketing Eggs

EGGS ARE DIFFICULT to market because of breakage, perishability, seasonal production, number of small lots sold, distance from production to markets, and a lack of consumer knowledge of the nutritive value of the product.

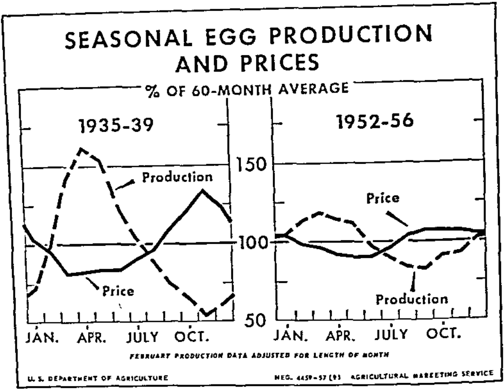
Marketing Problems

Egg Breakage. Eggs must be handled carefully to prevent breakage. Breakage occurs: in the nests before gathering; in gathering, cleaning, and packing for market; in transportation; in sampling, grading and cartoning; in delivery to egg counters in the stores; and on the way to the consumer's refrigerator. It is essential that eggs be handled with care and packaged in individual compartments or cells to reduce the chances of breakage (Fig. 10-3).

Egg Perishability. Eggs are much like milk with respect to keeping quality. The shell that covers an egg is not an airtight container. Nature provided the egg shell with pores for the entrance of oxygen and the escape of carbon dioxide during embryo development. The pores permit the escape of moisture and carbon dioxide and shrinkage of the egg contents. They also permit the entrance of microorganisms which cause spoilage. Therefore, eggs need to be gathered frequently, cooled quickly, kept in high humidity, cleaned, shell treated, and the time shortened as much as possible between production and consumption in order to maintain high quality and good flavor.

Seasonal egg production. Wild and domestic birds, including poultry, have a natural urge to lay eggs and reproduce young in the spring and early summer. This has resulted in high egg production in the spring and summer and low production during the fall and winter. The discovery of vitamins, especially vitamin D, has made it possible to raise birds indoors and all seasons of the year. Better housing has made it possible to provide spring-like conditions in the poultry house most of the year. Better feeding, housing, selection of breeding stock, and proper management practices are reducing the seasonal peak in egg production (Fig. 10-1). As a result, eggs are now more uniformly available, prices are lower and more uniform, consumption of eggs is greater, and there is less need for cold storage to hold eggs.

Many small lots of eggs to be marketed. Eggs are produced on more farms and in more backyards than any other agricultural food product. More than 60 per cent of the four million farmers in the United States have eggs



U. S. D. A., A. M. S.

Fig. 10–1. Seasonal egg production and prices.

for sale. Many of them have only a few dozen per week to be marketed. This creates a problem in getting them assembled and shipped in bigger lots to the consuming centers. The trend is toward fewer and larger egg production farms, resulting in better and more uniform quality of eggs marketed and lower costs of assemblying and marketing.

Distance between egg production and consuming centers. Most of the eggs are produced far away from the thickly populated consuming centers (Fig. 10–2). It appears to be more economical to produce eggs in grain producing regions and send the finished product to market than to ship the raw materials for this purpose Land and labor are usually cheaper the greater the distance from the big cities. Shell treating of eggs and use of refrigerated trucks is making it possible to deliver good quality eggs from surplus producing areas to deficit consuming centers.

Lack of consumer knowledge about the properties of eggs. The egg is probably the most complete food available to man. Evidence is the fact that an egg contains all of the essential nutrients for making a complete chick. Eggs have many functional uses and may be used in a variety of ways (Chapter 1). There is a lack of consumer information available on the nutritive value, care, and use of eggs. The Poultry and Egg National Board is providing valuable consumer education on these problems.

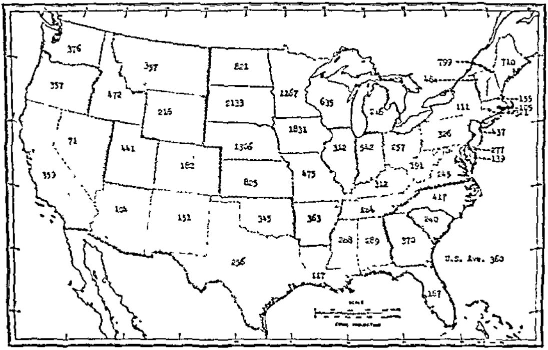


Fig. 10–2. Egg production ÷ population. 1958. States below the U. S. Average (360) and shaded are deficit areas.

Characteristics of Eggs

The egg is an unusual food product in that it contains all of the essentials except oxygen for growth of the species. It is an article of food and at the same time a reproductive cell. A greater appreciation of the market value of the egg may be gained by an understanding of its formation, structure, chemical composition, functional properties, and food value.

Egg formation. Details of egg formation have been described in Chapter 3. It requires about eight days for a yolk to develop to maturity and nearly 24 hours for formation of the egg after ovulation.

Structure of the egg. An appreciation of the structure of the egg is necessary to know how to handle and market it properly, and to acquaint consumers with its use. Details of the structure of the egg have been given in Chapter 3 and diagrammed in Fig. 3–17. High quality eggs have a small air cell, well centered yolk, high percentage of firm albumen, and sound shell. The chalaza, germinal disc and layers of dark and white yolk are normal in eggs. However, some consumers, not acquainted with egg structure, consider them as egg defects and objectionable.

Chemical composition of the egg. The egg consists of about 11 per cent shell and 89 per cent white and yolk. The egg contents consist of about 55 per cent white and 45 per cent yolk.

Functional properties of eggs. Eggs are used mainly for food (Chapter 1). In addition to their nutritional value, they function as leavening agents (cake baking) and as emulsifiers (preparation of mayonnaise). The

presence of a slight amount of yolk in white interferes with its beating properties. Strictly fresh white does not beat as well as white that is older. White that has been subjected to too much heat does not beat well. Space does not permit a discussion of the technology (physical chemistry) involved with the functional properties of eggs.

Food value of eggs. Eggs are a good source of proteins, minerals, and vitamins (Table 5—Appendix). They contain unidentified nutritional factors. Since eggs contain food nutrients for the development of the embryo, they provide a readily available, easily digested and complete food for infants, convalescents, and the aged. Further work based on newer analytical methods and nutritional measurements will no doubt show that eggs have even greater nutritional value than known at present.

Egg Quality

Egg quality is influenced by breeding (Chapter 4), nutrition (Chapter 8) and health (Chapter 9) of the layers. It is also influenced by the care of the eggs after they are laid. Quality of the egg begins to decline from the time it is laid and continues until it is consumed. Determination of quality of eggs determines their market value. Some of the measurements of quality are appearance (judging), candling, broken out examination (I.Q.), chemical analysis, microbiological analysis, and functional tests.

Judging eggs by appearance. Eye appeal is important in marketing any product and especially so in marketing eggs. Consumers want, above all, clean eggs. They also are willing to pay more for large eggs and those of uniform size, shape and color. Table 10–1 gives a score card for judging eggs by external appearance.

Table 10–1

JUDGING EGGS BY EXTERNAL APPEARANCE

Observation	Point Value	
	White Eggs	Brown Eggs
Size	24	24
Shape	6	6
Color	—	5
Uniformity of size	12	12
Uniformity of shape	12	12
Uniformity of color	10	5
Shell texture	24	24
Condition of shell	12	12

Candling eggs. Examination of the contents of an egg without breaking the shell may be done in a qualitative manner by candling. This quality measurement is done by holding the egg between the eye and a bright light (egg candler) in a darkened room (Fig. 10–3). One may observe the texture of

Fig. 10–3. Candling eggs.

Fig. 10–4. Some equipment used in measuring interior egg quality (I.Q.). (1) Glass plate with mirror. (2) Haugh unit scale. (3) Micrometer. (4) Egg shell thickness gauge. (5) Albumen height measuring device. (6) Salt solution for determining specific gravity. (7) Device for measuring width of yolk or albumen. (8) Color standards for yolk color.

the shell, the size of the air cell, the firmness of the white, the location and shadow of the yolk and the presence of foreign substances such as blood and meat spots by candling. Most of the types of spoiled eggs may also be detected by candling. One type, "green rot," may be detected in white shelled eggs by a special fluorescent candler which cannot be detected by an ordinary white light candler (Fig. 10–5). Egg standards of quality by candling used for determining market grades of eggs are shown in Table 10–2.

Table 10–2

SUMMARY OF UNITED STATES STANDARDS FOR QUALITY OF INDIVIDUAL SHELL EGGS

Quality Factor	Specifications for Each Quality Factor			
	AA Quality	A Quality	B Quality	C Quality
Shell	Clean, unbroken, practically normal	Clean; unbroken, practically normal	Unbroken, may be slightly abnormal, may show slight stains, but no adhering dirt	Unbroken and may be abnormal (in shape) and may have slight to moderate stained areas covering not over ¼ of the surface of the shell, but no adhering dirt.
Air Cell	One-eighth inch or less in depth, practically regular	Two-eighths inch or less in depth, practically regular	Three-eighths inch or less in depth, may show unlimited movement, and may be free but not bubbly	May be over three-eighths inch in depth and be free or bubbly
White	Clear, firm	Clear; may be reasonably firm	Clear; may be slightly weak	The white may be weak and watery so that the yolk may appear off-center and its outline plainly visible when the egg is twirled before the candling light
Yolk	Well centered outline slightly defined, free from defects	May be fairly well centered, outline may be fairly well defined, practically free from defects	May be off-center with its outline well defined when the egg is twirled before the candling light may appear slightly enlarged or slightly flattened and may show other definite but not serious defects	May appear dark, enlarged and flattened and may show clearly germ development, but no blood due to such development. Small blood clots and spots may be present

Broken-out examination of eggs for interior quality (I.Q.). Candling will detect cracked eggs, large blood and meat spots, and most types of rots. It will not detect sour or musty eggs (determined by odor), small blood and meat spots, small yolk imperfections and color, or the true condition of the white. A broken out examination is used for this purpose.

Appearance of the yolk and white may be observed from all angles by breaking the egg on a glass plate provided with a mirror (Fig. 10–4). Small yolk defects and small blood and meat spots not observed by candling may be found when broken out.

Odor examination of broken out eggs may detect sour, musty, "fishy" and other "off odors" not detected by candling.

Albumen characteristics are important indications of quality. They may be

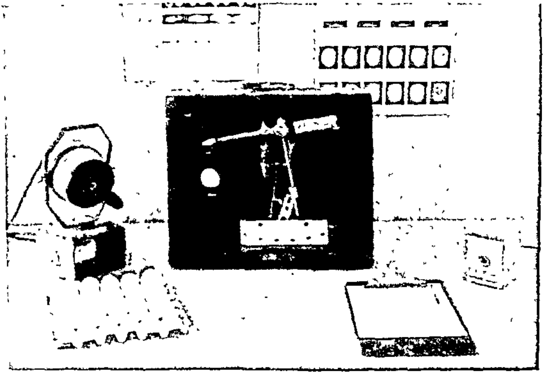


Fig. 10–5. Egg candlers. Fluorescent light at left and white light at right.

measured more accurately in the broken out examination of eggs than by candling.

Haugh unit is a measure of the albumen as judged by its height and the weight of the egg. The height is measured mid-way between the edge of the yolk and the outer edge of the firm white (Fig. 10–6). The eggs are weighed on a sensitive balance (Fig. 10–5). Conversion tables have been worked out

Table 10–3

ALBUMEN QUALITY, GRADES AND SCORES

U. S. Standard Grades	Haugh units	U. S. D. A. Scores (Fig. 10–7)
AA	100	1
	91	2
	83	3
A	75	4
	67	5
	59	6
B	51	7
	43	8
	35	9
C	27	10
	19	11
	11	12

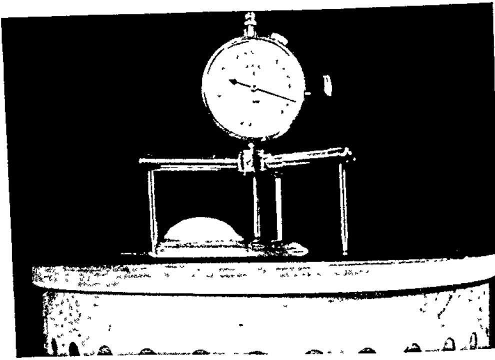


Fig. 10–6. Measuring albumen height, by means of a micrometer or height gage, midway between the edges of the thick white.

for converting albumen height and egg weight to Haugh units. These are listed on the albumen measuring devices. Other characteristics of eggs being normal, the relationship of egg grades and Haugh units are shown in Table 10–3.

Visual albumen score may be determined by comparison with a set of standards for egg grades which have been prepared by the United States Department of Agriculture (Fig. 10–7). A somewhat similar measurement is the Van Wagenen score. Visual comparison of albumen condition with a standard chart is a quick qualitative measurement of albumen quality.

Albumen index is the height divided by the diameter. It is used less than the Haugh or visual score.

Percentage of thick albumen is determined by measuring the per cent of total albumen that will pass through a screen of a given mesh when an egg is broken out on its surface. This measurement is sometimes used in research work.

Yolk color may be measured by comparing the broken-out yolk with a set of color standards (Fig. 10–4) or by extracting the coloring material with a fat extractive and comparing it with a set of dichromate solution standards.

Yolk index is the height of the yolk divided by the diameter. The nearer the index approaches 1.0, the better the quality of the yolk. Since the white begins to decline in quality before the yolk and is more sensitive to change, its properties are generally measured instead of those of the yolk when measuring egg I.Q.

Shell characteristics may be examined at the time of broken-out examina-

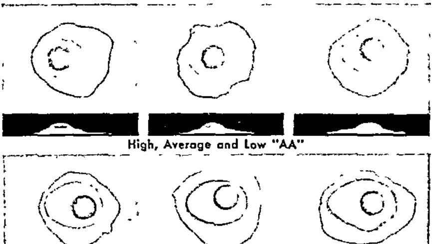


Fig. 10-7. Scores for albumen interior quality of eggs. (U. S. D. A.)

tion of egg contents. Breaking strength of shell, thickness, and porosity are some of the shell measurements made. Specific gravity of eggs (flotation in salt solutions) is sometimes measured (Fig. 10-4). The test measures porosity of shell by evaporation, increase in size of air cell, and the resulting lower specific gravity of eggs.

Chemical analysis. Routine analyses of eggs are sometimes made for moisture, crude protein, crude fat, and mineral content (Table 5, Appendix). The pH of eggs may give some indication of quality. As carbon dioxide escapes from egg white, the pH increases from near neutral (pH 7.0) to as high as 9.5. This is accompanied by the development of watery whites. White break-down (spoilage) is accompanied by the liberation of ammonia and in yolks by the liberation of foul-smelling sulfur compounds and acids, especially lactic acid.

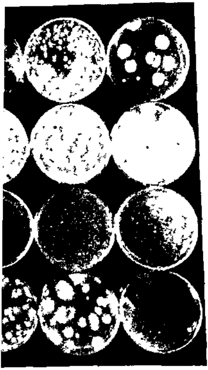


Fig. 10–8. Standard plate counts showing colonies of molds and bacteria.

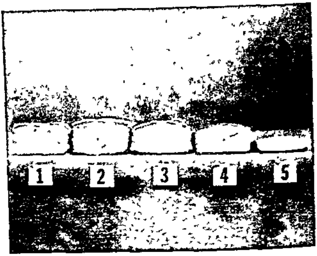


Fig. 10–9. Test of functional properties of eggs. Sponge cakes.

Microbiological analysis of eggs. Eggs are sometimes analyzed for organisms, usually bacteria, which may cause black or green rot spoilage; "blow-ups" in incubators; and food poisoning or high mortality of baby chicks, as caused by Salmonellas. Samples are first cultured on Petri dishes (*Fig. 10–8*) and the colonies (pure cultures) used for identification purposes.

Functional tests. Eggs or egg products (whites and yolks) may vary in their beating or emulsifying properties. This is more likely to occur after they have undergone some processing such as cleaning, shell treating, storage, etc.

Whipping tests are used to measure beating time and foam volume, specific gravity, and stability.

Cake baking tests are used to measure the leavening properties of egg yolk (sponge cakes, Fig. 10–9) and white (angel cakes). Cake volume is of primary importance. Other cake properties often considered are appearance, texture, tenderness, moisture, and flavor.

Emulsifying tests are used as a measure of the value of egg yolk. The egg mayonnaise test is commonly used. The greater the separation between liquid and solids in the mayonnaise mixture, the poorer the sample of egg yolk as an emulsifier.

Production of Quality Eggs

Breeding (Chapter 4), Housing (Chapter 7), Feeding (Chapter 8), and Diseases (Chapter 9), and possibly other factors influence the quality of eggs at time of production.

Breeding. There are breed, strain, family, and individual differences in egg quality. This is shown by differences in egg shell color, size and shape

of eggs, shell texture, presence of blood and meat spots, and albumen and yolk measurements.

Housing. Housing influences egg quality at the time of gathering by its influence on dirty eggs. A nest should be provided for every four or five layers. Clean nesting material should be used. Dry floor litter should be maintained on the floor. Otherwise, the soiled feet and feathers of the birds will result in an increase in the number of soiled eggs at time of gathering.

Feeding. The ration fed to layers influences the market quality and nutritional value of eggs (Chapter 8). Calcium and vitamin D influence shell quality; yellow pigmented feeds, yolk color; succulent feeds, firmness of albumen; cottonseed meal, yolk color; and garbage and litter, the flavor of eggs.

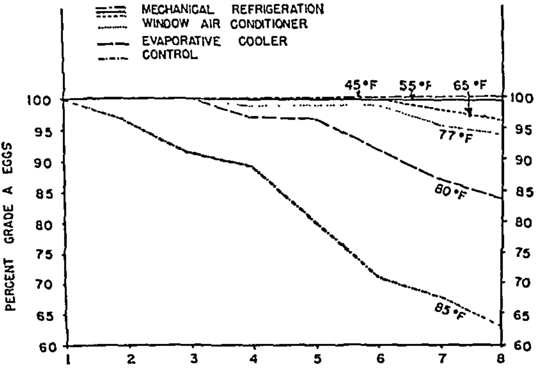


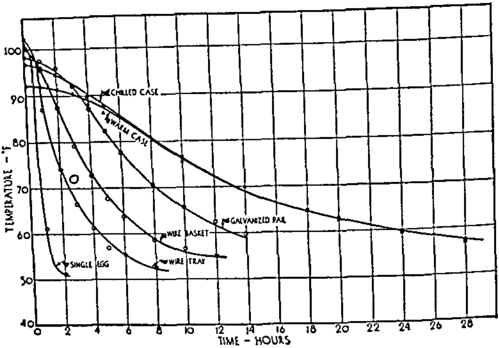
Fig. 10–10. Length of storage days (cumulative) and effect of storage and temperature on eggs.

The type of ration fed influences the nutritive value of the eggs produced. For instance, the vitamin content of the ration influences the vitamin content of the eggs.

Disease. Outbreaks of Newcastle disease or infectious bronchitis result not only in decreased egg production, but also cause abnormally shaped shells and "watery" whites with bubbly air cells. Other physiological disturbances result in yolk mottling, thin whites, and other abnormalities.

Care of Eggs on the Farm

Nearly all eggs are of high quality at the time they are laid. Decline in quality starts at once and continues first at an accelerated rate and then slower, until the eggs are used (Fig. 10–10). Quality deterioration can be slowed by



COURTESY MISSOURI AGRICULTURAL EXPERIMENT STATION

Fig. 10–11. Effect of container on the rate of cooling in eggs. (Egg room at 50° F.)

frequent gathering, quick cooling, proper cleaning, shell treating, proper packaging, good storage, and frequent marketing.

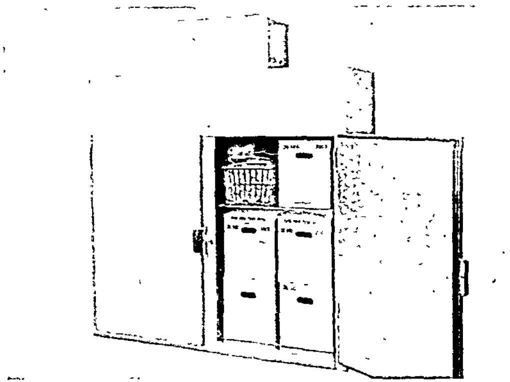
Gathering. Frequent gathering (three or more times daily) results in less breakage, fewer dirty eggs, and quicker cooling.

Cooling. Quick cooling retains quality. It may be accomplished by gathering in wire baskets (Fig. 10–11) and storing eggs in a cool damp basement or a mechanical egg cooler (Fig. 10–10 and 12) operated at about 55° F. dry bulb reading and 50° F. wet bulb reading (Fig. 10–18). Lower temperatures result in sweating when eggs are removed.

Cleaning eggs. Clean eggs are essential for good keeping quality and highest market value. From 10 to 80 per cent of all eggs gathered require some cleaning. The dirt may vary all the way from a speck to badly stained and soiled eggs. Slight amounts of dirt may be removed with a buffer (sandpaper) brush (Fig 10–13). Badly stained or soiled eggs need to be soaked in an approved detergent-sanitizer and the dirt rubbed off either by hand or mechanically. Some prefer to wash all eggs gathered (Fig. 10–13). They claim that too much labor is required in sorting the clean from soiled eggs. Another reason is that all eggs contain bacteria and mold spores on the shells at time of gathering even though no visible signs of dirt are evident.

Washing in a detergent-sanitizer is preferred to dry cleaning because it avoids shell abrasions, it is accomplished with less breakage, it is quicker, does a more thorough job of cleaning, and frees the shells from spoilage microorganisms.

Recommended egg washing practices based on Ohio Agricultural Experiment Station Research Bulletin 762 are:



COURTESY SUNSET EQUIPMENT COMPANY, ST. PAUL, MINNESOTA

Fig. 10–12. Mechanical egg cooler.

1. Use an approved detergent-germicide solution (the germicide is important).
2. Wash all eggs the day gathered.
3. Use a solution that feels slightly warm (100–110° F.) to the hand.
4. Use an amount of detergent-germicide recommended by the manufacturer (200 p.p.m. of Germicide).
5. Do not wash more than four or five dozen medium soiled eggs per gallon of solution.
6. *Do not wash off the detergent-sanitizer.*
7. Dry the eggs before packing.
8. Make up a new solution each day eggs are washed.
9. Do not wash eggs unless it is done properly.

Table 10–4

U. S. WEIGHT CLASSES FOR CONSUMER GRADES OF SHELL EGGS

Size or Weight Class	Minimum net weight per dozen	Minimum net weight for individual eggs per dozen
Jumbo	30 ounces	29 ounces
Extra large	27	26
Large	24	23
Medium	21	20
Small	18	17
Peewee	15	—

Fig. 10–13. Some egg cleaning methods. Top. Left. Hand buffing. Middle, hand washing. 1
Right. Machine washing by agitation of solution by bubbling air through it.

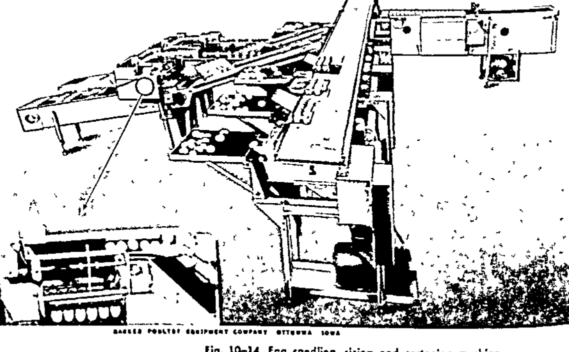


Fig. 10–14. Egg candling, sizing and cartoning machine.

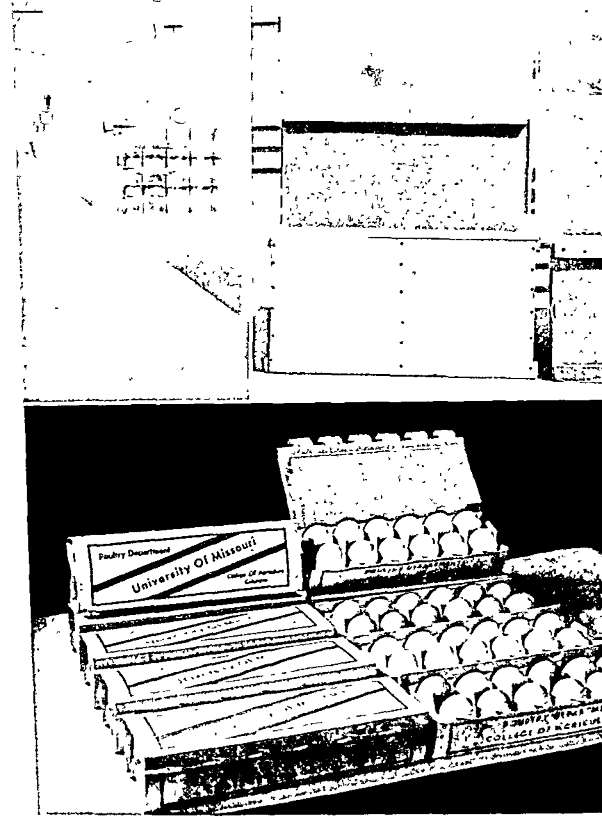
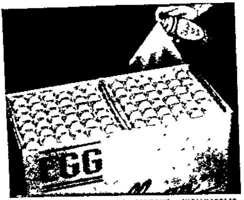


Fig. 10–15. Containers for marketing eggs. Upper left, frozen eggs (in foreground) being loaded in refrigerator car. (Courtesy Henderson Produce Company.) Upper right, egg cases made of wood and fiberboard for shipping eggs. Lower, egg cartons for retailing eggs.

Sizing eggs. A uniform pack of eggs is desirable. Large, medium, and other sizes should be packed separately (Table 10–4) An egg scale is suitable for small packing operations (Fig. 10–3). Larger farms often use an electrically operated automatic weighing scale (Fig 10–14).



COURTESY ANDERSON BOX COMPANY, INDIANAPOLIS, INDIANA

Fig. 10–16. Oil spray treatment of shell eggs.

Packaging eggs on the farm. Egg packaging materials (cases and cartons Fig. 10–3) should be kept in the egg storage room where it is cool and damp. As soon as eggs are thoroughly cooled (Fig. 10–11) or at least the day after gathering, they should be cased or cartoned, using clean filler-flats (Fig. 10–4) or separate flats and fillers (Fig. 10–3) and clean sound cases. Eggs do not dry out as rapidly when held in cases as in wire baskets.

Eggs sold at wholesale from the farm are usually packaged in 30-dozen size cases. If sold at retail, they are usually packaged in one-dozen size cartons (Fig. 10–15).

Oiling eggs on the farm. Eggs decline in quality by evaporation of moisture through the shell. This results in weight loss and larger air cells. Carbon dioxide also escapes through the pores. This results in an increase in pH and thinning of the white. These quality losses are greatest the first few days after eggs are laid (Fig. 10–10). They may be reduced by partially sealing the pores of the shell with a paraffin base mineral oil. It may be applied as a spray over the eggs on the flats or in the cartons (Fig. 10–16) or as a dip (Fig. 10–17) before the eggs are packaged (Table 10–5). A gallon of oil is sufficient to treat 20 or more cases of eggs and at a cost of less than three cents per case.

Table 10–5

INFLUENCE OF OILING EGGS ON PRESERVATION OF QUALITY *

Treatment	10 Days at 75° F.		12 Days at 50° F.	
	Haugh units	Wt. Loss	Haugh units	Wt. Loss
None	51	1855 mg.	70	729 mg.
Oil spray	68	280	74	228
Oil dip	75	200	79	122

* Swanson.

Thermostabilization. This process involves agitation of eggs in water or an egg treating oil at 130° F. for 15 minutes or at a higher temperature for a shorter period of time. It kills the germ in fertile eggs; pasteurizes the shell and shell membranes, destroying bacteria which cause spoilage (Fig. 10–20); and stabilizes the albumen which retards thinning and egg evaporation.

Shell Egg Marketing

Eggs should be marketed from the farm at least once a week. There are many outlets for eggs (Fig 10–19).

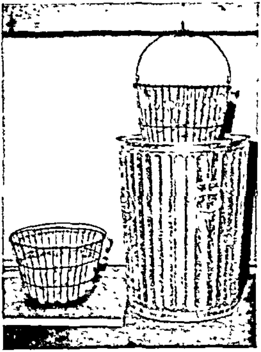
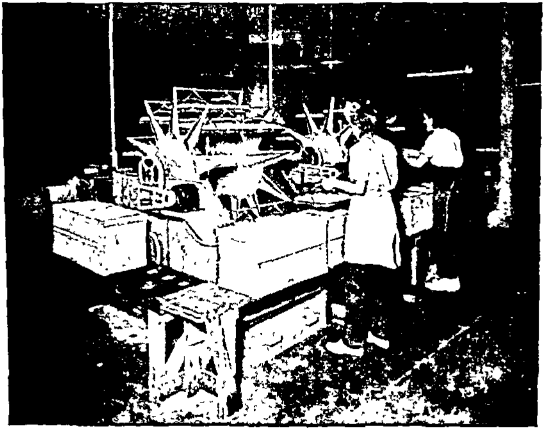


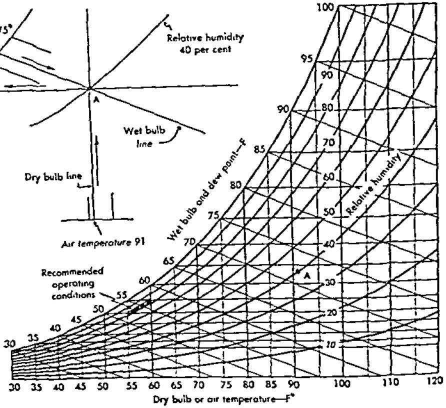
Fig. 10–17. *Right, eggs may be dipped in a can of oil on the farm and allowed to drain.*

Below, oil-dipping machines in use in an egg-packing plant.

COURTESY THE CAR PRO CO.



Marketing methods. Farmers near cities often market their eggs direct to consumers by egg routes or road-side stands. Egg vending machines are sometimes used (Fig. 10–21). Some farmers deliver or have their eggs picked up by egg cooperatives or independent dealers. They render several services in moving eggs from the farm to retailers.



U. S. D. A., A. M. S.

Fig. 10–18. Chart for establishing relative humidity and dew point.

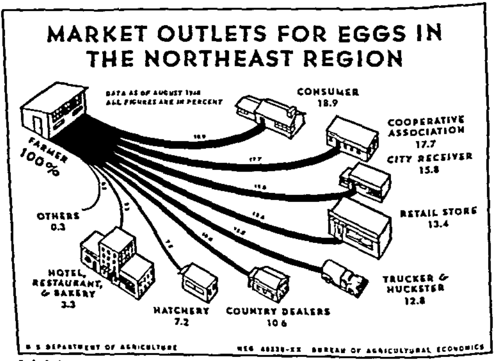


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Fig. 10–19 Methods of marketing eggs from farms.

Assembly of eggs. Most eggs are picked up at the farms on egg routes and hauled to the assembly plants in insulated trucks (Fig. 10–22). The empty cases are exchanged for the full ones. Most pick-ups are made once a week. The eggs are delivered to cool, humid, egg-holding rooms until candled and packed for mar-

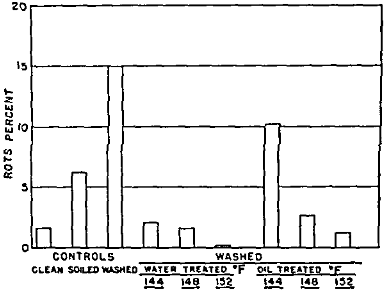
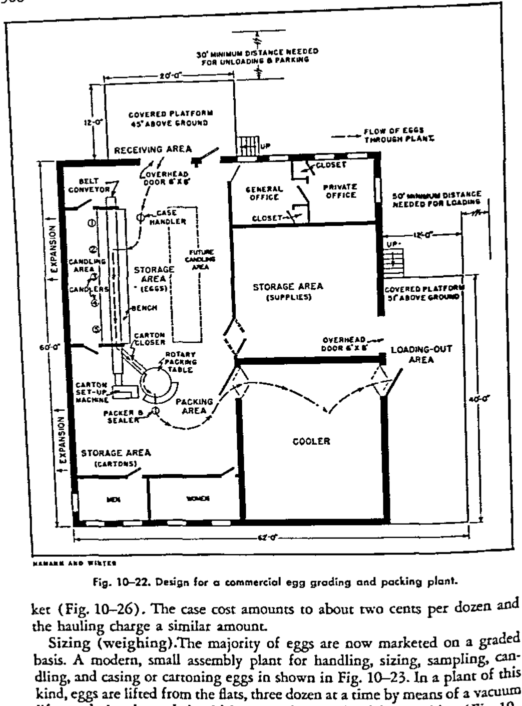


Fig. 10–20. Spoilage of washed eggs agitated in hot water or oil for two minutes and held 3 weeks at 80° F.

COURTESY D. AND D. VENDING MACHINE CO., SAN JOSE, CALIFORNIA

Fig. 10–21. Egg vending machine.



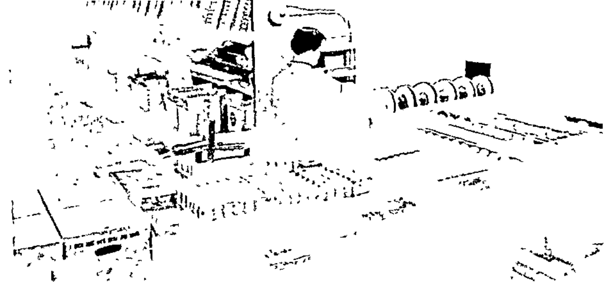
HAMANN AND WINTER

Fig. 10–22. Design for a commercial egg grading and packing plant.

ket (Fig. 10–26). The case cost amounts to about two cents per dozen and the hauling charge a similar amount.

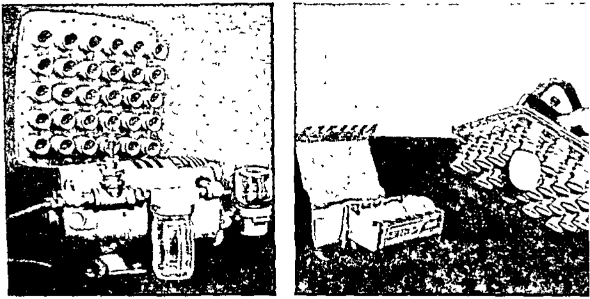
Sizing (weighing).The majority of eggs are now marketed on a graded basis. A modern, small assembly plant for handling, sizing, sampling, candling, and casing or cartoning eggs in shown in Fig. 10–23. In a plant of this kind, eggs are lifted from the flats, three dozen at a time by means of a vacuum lifter and placed on a belt which moves them to the sizing machine (Fig. 10–24). Eggs of different weights are dropped into different channels and carried on a belt to the candlers.

Sampling. Some assembly plants size, candle, count, and pay the producer for all grades and sizes of eggs in each shipment. A more modern and time-saving method is to pay for the entire shipment on the basis of a sample of eggs in the shipment. This may be based on the size of eggs in the sample and



COURTESY PAGE DETROIT, INC., DETROIT, MICH.

Fig. 10–23. An assembly plant for sizing, grading and packing eggs.



FOOD SYSTEMS, INC., OAKLAND, CALIFORNIA

Fig. 10–24. Vacuum egg lifter. Will pick up and release a layer of eggs at a time from a filler flat.

their candled or broken out (I.Q.) quality as determined by Haugh units (Table 10–3).

Candling. In the plant shown in Fig. 10–23, the eggs of different sizes are carried along on a belt and diverted to the side (a different size to each candler). Here the eggs are candled for cracks and interior quality and are then packaged. Assembly plant candling, record keeping, packaging and selling costs amounts to 2 to 4 cents per dozen.

PAGE DETROIT, INC., DETROIT, MICHIGAN

Fig. 10-25. Cartoned eggs pass from candling room through closing, sealing and stamping machines at far end of line and along conveyor for packaging.

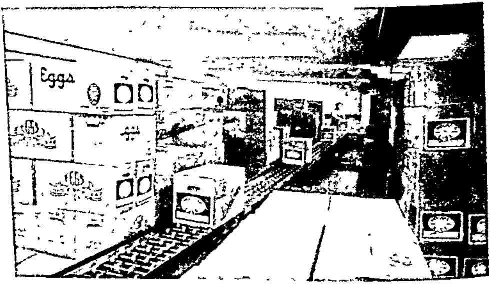


Fig. 10-26. Eggs are moved to and from cool, humidified holding rooms on roller bearing conveyors.

COURTESY FOOD SYSTEMS, INC., OAKLAND, CALIFORNIA

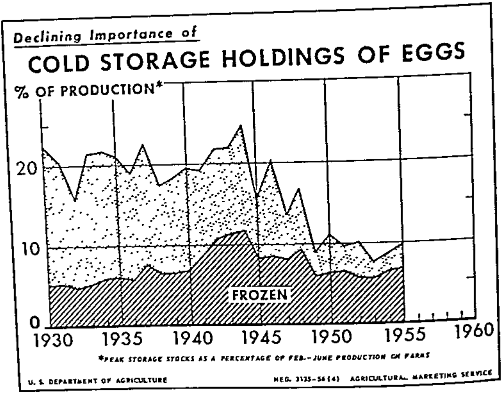
COURTESY FOOD MACHINERY AND CHEMICAL CORPOR CALIFORNIA

Fig. 10–27. Automatic egg blood spot detector. Fig. 10–28. Candled eggs are placed according to grade on any one of eight shuffle feeders in front of candler and cracked and blood spot eggs on filler-flats.

COURTESY FOOD MACHINERY AND CHEMICAL CORPORATION, RIVERSIDE, CALIFORNIA

Fig. 10–29. Candling stations in a large assembly plant. From here the eggs are automatically sized, recorded, oiled, cartoned sealed, dated and delivered to the packaging table.

Eggs of high quality need no examination except for cracked shells and blood spots. They may be handled mechanically for this examination in the larger assembly plants. The eggs are lifted, three dozen at a time, by means of a vacuum lifter (Fig. 10–24) to a conveyor which passes them over lights. This permits picking out the cracked eggs and those with large blood and



U. S. D. A., A. M. S.

Fig. 10–30. Cold storage holdings of the eggs.

Fig. 10–31. Egg display case in supermarket.

meat spots and other prominent interior abnormalities. They may also be passed through a blood spot detector which will roll out eggs with blood or meat spots of all sizes (Fig. 10–27).

In large assembly plants, elaborate egg grading, sizing, counting, dating,

reating, and cartoning machines are used. (Fig. 10–28 and 29). It speeds the candling operation from 30 to 40 cases per worker per day to 60 nore. It also simplifies the record keeping.

ackaging. Eggs are packaged according to size and grade into cases or ons. If cartoned, the one-dozen egg cartons are carried on another belt ugh a carton closing, sealing, and dating machine (Fig. 10–25), and on packaging table. From here the cartons are packed in 15-dozen non-rnable cardboard boxes or in 30-dozen egg cases.

Iolding. The boxes or cases of eggs move on conveyors (Fig. 10–26) to ir conditioned and humidified room where they are held until shipment.

ransportation. Cases of eggs are generally moved from the assembly its to the large city terminal warehouses by refrigerated trucks, which hold to 600 cases or more. The cases are packed end to end, to reduce break-in transit. Some eggs are also moved by refrigerated railway cars, the acity of which is about the same as that of large refrigerated trucks. The of trucking eggs from the surplus producing assembly centers to the e consuming centers amounts to two or three cents per dozen.

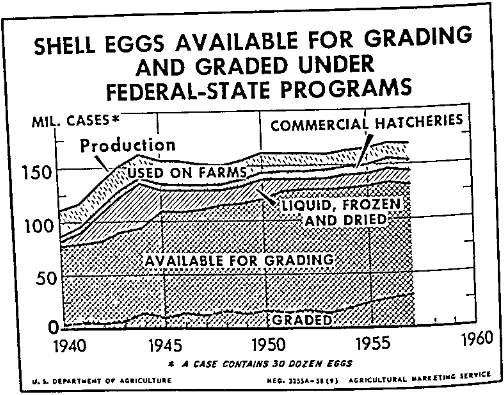
Terminal cold storage of eggs. Storage of the surplus eggs in the spring their sale in the fall and winter was an important part of egg marketing ore more uniform production throughout the year became a more general ctice (Fig. 10–30). Shell egg cold storage rooms are maintained at about –32° F. and 80 to 90 per cent relative humidity. Eggs to be held in d storage are usually oiled (Fig. 10–17). The charge for storing eggs is ut 2 cents per dozen the first month and ½ cent for each additional month.

Wholesale distribution of eggs. Some eggs are sold in case lots at olesale (reduced price) to large users such as hotels and restaurants.

Retailing eggs. Most of the eggs sold in large cities are retailed through supermarkets to housewives (Fig. 10–31). The margin for the retailer is ially 8 to 10 cents per dozen. The retailer needs to provide refrigerated play cases for holding eggs. Most states have laws which govern advertising eggs. For instance, the Ohio egg law states that eggs advertised as fresh st be of Grade A quality or better (Table 10–2) and those advertised as ge must weigh 24 ounces per dozen (Table 10–4).

Frozen Egg Marketing

The frozen egg industry. The freezing of eggs started soon after the velopment of central cold storage freezing facilities. It was first used as a ans of salvaging cracked, abnormally shaped, and soiled eggs. Now most the eggs that are broken out for freezing are of good market value because the greater demand for frozen eggs (Fig. 10–30). The frozen and dried g business remains about 5 per cent of the total egg business (Fig. 10–32). ost of the egg breaking and freezing plants are located in the midwest sur-as egg producing areas, especially in Minnesota, Kansas, Missouri and wa. Peak operations are in the spring of the year when there is a large sur-as of shell eggs and prices are low.



U. S. D. A.

Fig. 10–32. The use of eggs.

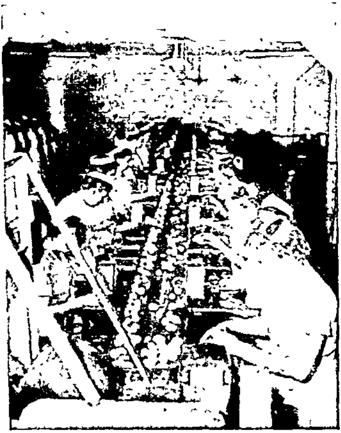
Advantages of frozen eggs over shell eggs are: (1) less storage space required (Table 6, Appendix), (2) keeping quality does not decline during storage, (3) cheaper, (4) less labor required in preparation for use, and (5) the purchaser need buy only the part needed, white or yolk.

Uses of frozen eggs are mainly for bakery goods, salad dressing, candy, and noodle production.

Egg breaking. Eggs are washed, if soiled, candled and broken individually by hand (Fig. 10–33) or by machine (Fig. 10–34). The contents are observed for abnormalities and smelled for off odors. The whites and yolks may be separated. High quality eggs are necessary for this purpose in order to avoid yolk seepage or broken vitelline membranes. The presence of a trace of yolk in egg white interferes with its beating properties.

Whole eggs are mixed and strained before packaging. *Yolks* are handled in a similar manner Salt or sugar (up to 10 per cent by weight) is often mixed with yolk before freezing to reduce its rubbery consistency after freezing and defrosting. Glycerine, molasses, or honey may also be used for this purpose. *White* is strained to remove chalaza, meat or blood spots, and shell fragments. It may be run through a chopper to mix the thick and thin white and reduce beating time.

Sanitation is important in the egg breaking plant to prevent high bacterial count in the liquid egg. All equipment must be thoroughly cleaned at the end of each day and more often in warm weather.



INSTITUTE OF AMERICAN POULTRY INDUSTRIES, CHICAGO, ILLINOIS

Fig. 10–33. Modern egg-breaking plant in operation. Fig. 10–34. Liquid egg pasteurization with plate heat exchangers.

Pasteurization. Liquid whole egg, yolk or white, may be pasteurized much the same as milk in order to destroy pathogenic bacteria, especially Salmonellas, and to prolong keeping time. Pasteurization of whole egg at 140° F.–142° F. for 3 to 3½ minutes is sufficient to kill Salmonellas. Egg white must be pasteurized at a temperature not higher than 135° F. *Bacteria are killed more easily by pasteurization when they occur in white than in liquid* whole egg or milk. This is probably because of the lysozyme content of egg white.

Packaging liquid egg for freezing. Thirty pound metal cans are generally used (Fig. 10–35). Smaller containers may find greater use in the future as they hold amounts more suitable for small bakery, restaurant, or home use. The containers should not be filled completely before freezing. Expansion of *the egg during freezing may break the container or push the lid off.*

Freezing eggs. Eggs should be frozen at 0° F. or lower. Forced circulation of air around the containers will reduce the freezing time about 50 per cent.

Storage of frozen eggs. Frozen eggs will keep indefinitely. However, long storage is not advisable because of the cost involved.

Defrosting frozen eggs. Eggs should be defrosted as quickly as possible and used soon afterwards in order to prevent growth of bacteria. Defrosting *of cans of frozen eggs in a stream of running cold tap water is satisfactory* It requires 8 to 12 hours to defrost a 30-pound can by this method.

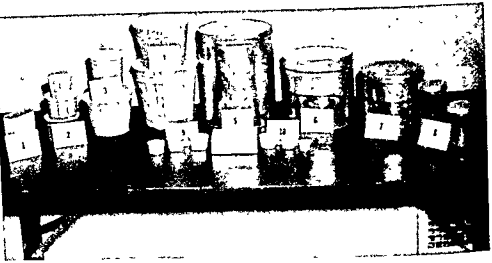


Fig. 10-35. Frozen egg containers ranging from a single yolk (10) to 30 pound cans (5).

Quality standards for frozen eggs. Specifications established by the Quartermaster Corps of the armed forces for the purchase of frozen egg products are:

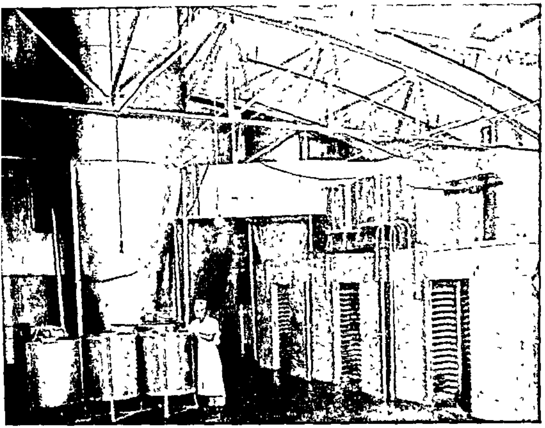
Product	Solids	Standard plate bacterial count per gram
Whole egg	25.5 per cent	500,000
White	11.5 per cent	20,000
Yolk	43.0 per cent	100,000

Other factors considered in judging quality of frozen egg products are coliform bacterial count, texture, sediment, color, and odor.

Uses of frozen egg products. Frozen whole eggs may be prepared the same as shell eggs unless individual eggs are required as in poaching. Frozen and shell egg equivalents are listed in Table 6, Appendix. Frozen egg yolk is used in baking (sponge cakes), baby foods, and mayonnaise production. Frozen egg white is used in baking (angel cakes) and in candy manufacture.

Dried Egg (Egg Solids) Marketing

The dried egg industry. Dried eggs keep better and require less space than shell eggs (Table 6, Appendix). Long distance shipment and lack of refrigeration favors the use of dried eggs. The egg drying industry was of considerable importance in China about 1930. Dried egg products were imported to this country. During World War II, egg drying was increased in the United States as a means of supplying a highly nutritious and concen-



COURTESY TRANNIN EGG PRODUCTS COMPANY, KANSAS CITY, MISSOURI

Fig. 10–36. Egg drying plant. Spray drying (left) and pan drying (right).

trated food for our field armed forces overseas. Since the war, egg drying has declined (Fig. 10–32). However, the development of prepared food mixes, such as cake mixes, has stimulated the drying of eggs for these products. Bakers and other users of frozen eggs would use dried eggs to a greater extent, because of convenience, if they were less costly (Table 10–6).

Egg drying. Liquid whole egg and yolk are generally dried by a vacuum spray process much like the drying of milk (Fig. 10–36). The egg is usually pre-heated to about 140° F. in a plate heat exchanger, and forced under pressure through fine nozzles as a spray or mist into a large chamber containing heated air (approximately 210° F. at intake and 180° F. at exhaust). The mist is dried almost instantly and falls as a fine powder to the bottom of the chamber where it is removed. The dried egg may be blown through a second chamber where the moisture is further reduced. It is cooled and sifted to remove lumps and then packaged, preferably in air tight containers under partial vacuum with air being replaced by carbon dioxide and nitrogen.

Glucose removal from whole egg and white before drying improves the quality by reducing darkening and improving solubility of the powder. The glucose may be removed by fermentation in vats with glucose-oxidase and catalase enzymes, with yeast or with certain bacteria.

Egg white may be dried in the same manner as whole egg or yolk or in shallow pans (Fig. 10–36).

Table 10–6

SEASONAL PRICE OF SHELL, FROZEN, AND DRIED EGGS *

Product	Jan.	April	July	October
Shell Eggs				
Large A per dozen..........	43.70¢	41.86¢	44.66¢	49.59¢
Frozen Eggs				
Whole egg per pound.......	29.75¢	31.00¢	31.25¢	28.50¢
White per pound...........	16.25	13.50	13.00	11.75
Yolk per pound (salted).....	50 00	50.75	52.50	48.75
Whole shell egg equiv. (10.2 eggs = 1 pound).....	34.80¢	36.27¢	36.56¢	33.34¢
Dried Eggs				
Whole egg per pound........	$1.23	$1.21	$1.22	$1.12
Yolk per pound............	1.34	1.30	1.34	1.25
White per pound...........	1.42	1.19	1.11	1.06
Whole shell egg equiv. (36 eggs = 1 pound)......	41.00¢	40.30¢	40.60¢	37.30¢

* New York wholesale prices. 1958. U S D.A., A.M.S., Statistical Bulletin 252. 1959.

Frozen eggs may be defrosted and dried. Cans of frozen eggs are frequently moved from breaking plants to a centrally located drying plant, defrosted, de-sugared, and dried as the capacity of the dryer will permit. Egg drying plants are more costly to construct and operate than egg freezing plants. Consequently there are fewer of them in operation but they are in use a greater per cent of the time.

Dried egg standards. The Quartermaster Corps of the armed forces buys dried whole eggs on the following specifications:

Analysis	Average, not more than	Maximum
Moisture	2.3 per cent	2.5 per cent
Glucose content	0 03 per cent	0.05 per cent
Standard plate count	50,000 per gram	75,000 per gram
Coliform count	50 per gram	100 per gram
Yeast and mold count	20 per gram	50 per gram
pH	Not less than 7,	nor more than 7.9
Oxygen content	Not more than 2 per cent	

Use of dried eggs. Dried eggs may be reconstituted and used for scrambled eggs or in baking recipes much the same as shell eggs. Shell, frozen, and dried egg equivalents are summarized in Table 6, Appendix.

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Chapter 11

Marketing Poultry

MARKET POULTRY includes chickens, turkeys, and waterfowl. Chicken broilers are the chief source of income from poultry meat (Fig. 1–7). In 1958 their sales amounted to $1 billion. Poultry meat production, especially chicken broilers and turkeys, has had a more rapid increase than the production of other farm animals (Fig. 1–6). Better breeding, feeding, managing, marketing, processing, and distributing have kept the price of poultry meat relatively stable while the cost of other foods has risen. The low price and high nutritional value of poultry meat has stimulated consumption. It will probably continue for some time (Fig. 1–9 and Table 1–8).

Poultry Marketing Problems

Many producers. Over 60 per cent of all farmers raise poultry and most of them have a surplus for sale. The number may vary from a few birds on general farms, to many thousand from specialized broiler, turkey, or waterfowl farms.

Seasonal marketing. While the surplus of eggs is produced in the spring, that of poultry occurs in the fall, because old birds are sold to make room for pullets to be housed. Generally, turkeys are marketed in the fall. The fall crop of broilers marketed from broiler farms must compete with these general sources.

Distance from market. There is a surplus of poultry meat produced in certain areas. A large surplus of broilers is produced in the states of Alabama, Arkansas, Delaware, and Maine (Fig. 11–1), and a surplus of turkeys in Arkansas, Iowa, Minnesota, Utah, and Virginia (Fig. 13–12). The surplus poultry has to be processed and moved to large consuming centers such as New York, Chicago, and Los Angeles.

Perishability of product. Most poultry meat is marketed as fresh slaughtered, ice packed, or refrigerated-tray packed. The temperature must be kept below 40° F. to keep the product for a week. Most processing plants do not have sufficient refrigeration to freeze and hold poultry when there is a surplus and prices are low. It has to be sold regardless of market price.

Marketing Live Poultry

Demand for live poultry. Some years ago, most live poultry was shipped to consuming centers and the birds were sold individually to consumers. Some

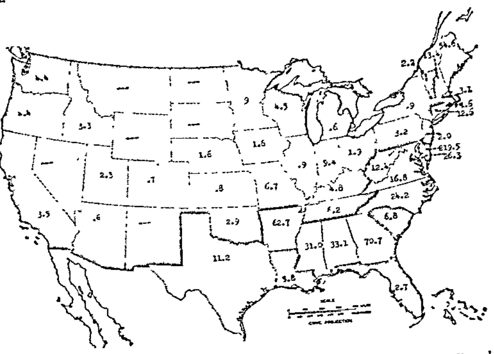


Fig. 11–1. Broilers raised ÷ population. 1958. States below the U. S. average (9.9) and shaded are deficit areas.

of the buyers dressed their own birds while others employed the service of local dealers. The practice has declined because of sanitation problems in cities, the high cost of labor, better transportation and refrigeration, and the desire of consumers to buy food ready-to-cook or food already cooked.

Jewish people, who formerly purchased live birds and had them slaughtered by a representative of the rabbi known as a "*schochet*," are buying ice-packed and frozen poultry. However, the Jewish holidays, especially the Passover in the spring and the Day of Atonement in the fall, create some demand for live poultry in the large city markets.

Market classes of live poultry. Formerly, poultry producers and buyers from diverse localities, would often use different terminology when trading poultry. This led to confusion in buying and selling. The United States Department of Agriculture, with the cooperation of poultry producers, buyers, processors, and retailers, has since formulated a common terminology. The United States market classes of live poultry are:

a. Chickens

1. Broilers and fryers: Young chickens of either sex (usually under sixteen weeks of age), tender-meated, with soft, pliable, smooth-textured skin, and flexible breastbone cartilage.
2. Roasters: Young chickens of either sex (usually under eight months of age), tender-meated, with soft, pliable, smooth-textured skin. Breastbone cartilage somewhat less flexible than in broilers and fryers.
3. Capons: Unsexed male chickens (usually under ten months of age), tender-meated, with soft, pliable, smooth-textured skin.

4. Stags: Male chickens (usually under ten months of age) with somewhat toughened and darkened flesh, coarse skin, and considerable hardening of the breastbone cartilage. Stags show a condition of *fleshing and maturity intermediate between that of roasters and cocks.*
5. Hens, stewing chickens, fowl: Mature female chickens (usually more than ten months old) with meat less tender than a roaster, and with a nonflexible breastbone.
6. Cocks (old roosters): Mature male chickens with toughened and darkened meat, hardened breastbone, and coarse skin.

b. Turkeys
1. Fryers or roasters: Young turkeys of either sex (usually under sixteen weeks of age), *tender-meated, with soft, pliable, smooth-textured skin,* and flexible breastbone cartilage.
2. Young hen turkeys: Young female turkeys (usually under eight months of age), tender-meated, with soft, pliable, smooth-textured skin, and flexible breastbone cartilage.
3. Young tom turkeys: Young male turkeys (usually under eight months of age), tender-meated, with soft, pliable, smooth-textured skin, and flexible breastbone cartilage.
4. Hen turkeys: Mature *female turkeys (usually over ten months of age),* with toughened flesh and hardened breastbone. May have coarse or dry skin and patchy areas of surface fat.
5. Tom turkeys: Mature male turkeys (usually over ten months of age), with toughened flesh, coarse skin, and hardened breastbone.

c. Ducks
1. Broiler and fryer ducklings: Young ducklings of either sex (usually under eight weeks of age), tender-meated and with soft bills and windpipes.
2. Roaster duckling: Young ducks of either sex (usually under sixteen weeks of age), tender-meated, and *with bills not completely hardened* and easily dented windpipes.
3. Mature (old) ducks: Mature ducks of either sex (usually over six months of age), with toughened flesh, hardened bills, and hardened windpipes.

d. Geese
1. Young geese: Young geese of either sex, tender-meated and with easily dented windpipes.
2. Mature (old) geese: Mature geese of either sex, with toughened flesh and hardened windpipes.

e. Guineas
1. Young guineas: Young guineas of either sex, and tender-meated.
2. Mature (old) guineas: Mature guineas of either sex, with somewhat toughened flesh.

f. Pigeons
1. Squabs: Young, immature pigeons of either sex, extra tender-meated, that have not flown.

Table 11–1

SUMMARY OF STANDARDS OF QUALITY FOR LIVE POULTRY ON AN INDIVIDUAL BIRD BASIS
[Minimum Requirements and Maximum Defects Permitted]

Factor	A or No. 1 Quality	B or No. 2 Quality	C or No. 3 Quality
Health and vigor	Alert, bright eyes, healthy, vigorous.	Good health and vigor.	Lacking in vigor.
Feathering	Well covered with feathers showing luster or sheen.	Fairly well covered with feathers.	Complete lack of plumage feathers on back.
	Slight scattering of pin feathers	Moderate number of pin feathers	Large number of pin feathers.
Conformation	Normal	Practically normal	Abnormal.
Breastbone	Slight curve, 1/8-inch dent (chickens), 1/4-inch dent (turkeys).	Slightly crooked	Crooked.
Back	Normal (except slight curve)	Moderately crooked	Crooked or hunched back.
Legs and wings	Normal	Slightly misshapen	Misshapen.
Fleshing	Well fleshed, moderately broad and long breast.	Fairly well fleshed	Poorly developed, narrow breast, thin covering of flesh.
Fat covering	Well covered, some fat under skin over entire carcass.	Enough fat on breast and legs to prevent a distinct appearance of flesh through skin.	Lacking in fat covering on back and thighs, small amount in feather tracks.
	Chicken fryers and turkey fryers and young toms only moderate covering. No excess abdominal fat.	Hens or fowl may have excessive abdominal fat.	
Defects	Slight	Moderate	Serious.
Tears and broken bones	Free	Free	Free.
Bruises, scratches, and calluses.	Slight skin bruises, scratches, and calluses.	Moderate (except only slight flesh bruises).	Unlimited to extent no part unfit for food.
Shanks	Slightly scaly	Moderately scaly	Seriously scaly.

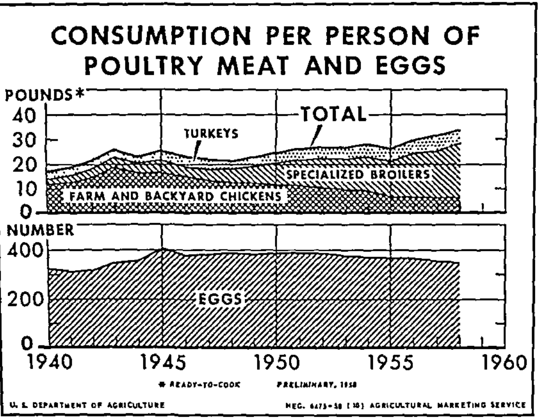


Fig. 11–2. Changes in consumption of poultry products 1940–58.

2. Pigeons: Mature pigeons of either sex, with toughened flesh and coarse skin.

Standards of quality (grades) of live poultry. Most live poultry has been sold by the pound with little attention paid to the quality. Poultry buyers, processors, retailers and consumers are becoming more quality minded. Consequently, buyers are beginning to pay more attention to the quality of the birds they buy. This is an advantage for both the producer and the consumer. Those who produce birds that are healthy, uniform in appearance, well feathered, meaty, and better finished deserve a premium price for their stock. Buying on the basis of quality is especially noticeable at live poultry auctions, such as those in operation in Maryland and Georgia. The factors considered in classifying live birds as A, B, or C quality are given in Table 11–1.

Production of quality poultry. Some years ago, many birds brought to market were those culled from the flock because they were poor producers, either from disease or age. Today, layers are not kept as long and are less likely to be diseased (Table 9–4), and a higher percentage of the total poultry marketed are broilers. Disease among broilers (Table 9–3) is now kept at low level (Table 4–11). Healthy flocks are being raised through good breeding, feeding, and management practices; and as a result, the birds are more uniform in size and finish when marketed.

Fattening was formerly practiced before birds were slaughtered. Birds received from farms where they had not been properly fed, were placed in

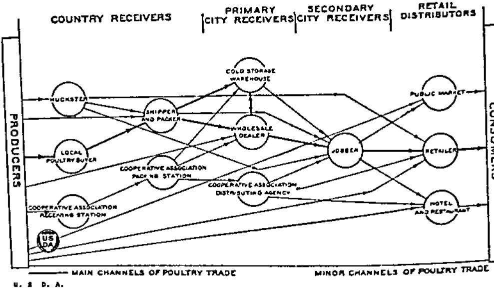


Fig. 11–3. Market channels for poultry.

batteries and fed a fattening feed one to two weeks before slaughter (p. 278). During this period, the birds frequently gained 5 to 25 per cent in weight and the quality of meat was improved. Today, most poultry is fed properly on the farms and there is no need for a fattening period.

Hormone injection (Fig. 6–16) or feeding (p. 177) may be used to improve the finish of young chickens or turkeys, which are not usually fat. Hormones do not improve growth rate or feed efficiency; therefore, unless a higher price may be received for a better finish (fat), it is doubtful if hormonization is justified.

Selling and buying live poultry. Market quotations, class of poultry, market quality (grade), size of shipment, distance from market or processing plant, marketing method (Fig. 11–3), and other factors influence the price paid or received for poultry.

Market quotations. Market quotations are generally based on supply and demand (prices paid) in a large producing area. For example, in 1959 the North Georgia broiler market quotations had an influence on prices paid in other sections of the country, because the volume of broilers produced in the area was larger than elsewhere (Table 1–4). For comparison, Ohio broiler prices were generally ½ to 1 cent per pound higher than the North Georgia prices, because broilers produced in Ohio were closer to large consuming areas. The extra price paid covered the increased trucking charge from Georgia to Ohio.

The United States Department of Agriculture, in cooperation with state departments of agriculture, publishes daily market reports covering poultry and egg prices in the main producing areas. They are useful guides for both the sellers and buyers of live poultry.

The class of poultry influences the price paid. For instance, the price paid for chicken roasters is considerably higher than that paid for old hens (Table 11–2).

Table 11–2

SEASONAL PRICES OF LIVE AND PROCESSED POULTRY. NEW YORK CITY. 1958
(Cents per pound)

Species and Classes	Jan.	April	July	Oct.
LIVE POULTRY *				
Chickens				
Broilers and Fryers	24.47	27.75	26.21	23.31
Caponettes (5 lbs. +)	27.67	32.44	30.33	27.82
Fowl (hens)	24.21	29.63	25.27	18.44
PROCESSED POULTRY **				
Turkeys [1]				
Heavy Breeds:				
hens	43.50	50.50	43.50	40.75
toms	34.50	37.75	38.75	36.00
Light Breeds (all)	43.25	47.25	43.50	40.25
Fowls [1] (hens)				
3–3½ lbs. (Retail Pack)	34.50	38.75	38.50	33.00
3–3½ lbs. (Cut-up Tray Pack)	36.50	41.25	40.25	35.50
4–4½ lbs. (Retail Pack)	35.50	40.50	39.50	34.00
4–4½ lbs. (Cut-up Tray Pack)	36.50	41.75	40.25	35.50
Caponettes [2]				
4 lbs.	38.00	49.00	38.00	38.00
5 lbs.	44 00	53.50	46.00	42.00
6 lbs.	45.00	53.50	46 00	42.00
7 lbs.	*45.00*	*53.50*	*46.00*	*42.00*
Ducks [1]				
under 5 lbs.	42.00	43.25	39.75	41.75
5 lbs. and over	43.00	44.25	39.75	43.00
Geese				
6–8 lbs.	38.00	No	No	No
10–12 lbs.	48.00	price	price	price
12–16 lbs.	51.50	reported	reported	reported
Guineas [1] (young)				
1¼–2¼ lbs.	69.00	69 00	62.50	62.50
Squab [3]				
Graded 11 lbs. & up to dozen	90.00	95.00	80 00	75.00
Graded under 11 lbs. to dozen	70 00	75.00	70.00	70 00
Rock Cornish Game Hens [1]				
12–14 oz. each	85.00	85.00	85.00	70.00
16–18 oz.	75 00	75 00	75.00	70 00
2–2½ lbs.	51.50	51.50	51.50	47.50

* *Dairy and Poultry Market Statistics 1958.*
** *Producers' Price Current.*
[1] Quick Frozen and Eviscerated.
[2] Iced, Crated and Eviscerated.
[3] New York Dressed.

The quality (grade) of poultry sold influences the price received per pound. Flocks of grade A birds *may bring ½ to 2 cents per pound more than* flocks which have many grade B birds.

The distance from the market or processing plant influences the price paid. Birds close to market generally bring ½ to 1 cent per pound more than those trucked more than 100 miles.

Table 11–3

SUMMARY OF STANDARDS FOR QUALITY OF DRESSED AND READY-TO-COOK CHICKENS
[Minimum requirements and maximum defects permitted]

Factor	A Quality		B Quality		C Quality
Conformation	Normal		Practically normal		Abnormal (If fairly well fleshed)
Breastbone	Slight curve, ⅛-inch dent		Dented, curved, slightly crooked		Seriously crooked (If fairly well fleshed)
Back	Normal (except slight curve)		Moderately crooked		Seriously crooked (If fairly well fleshed)
Legs and wings	Normal		Moderately misshapen		Misshapen
Fleshing	Well fleshed, moderately long and broad breast.		Fairly well fleshed on breast and legs.		Poorly fleshed
Breastbone	Not prominent		Not prominent		May be prominent
Fat covering	Well covered—some fat under skin over entire carcass. Broilers or fryers only moderate covering.		Sufficient fat on breast and legs to prevent distinct appearance of flesh through skin.		Lacking in fat covering over all parts of carcass
	Breast and legs	Elsewhere	Breast and legs	Elsewhere	
Pinfeathers:					
Dressed: Pins and hair	Practically free	Practically free	Relatively few	Slight scattering.	Numerous
Ready-to-cook:					
Nonprotruding pins	Practically free	Practically free	Few scattered	Few scattered	Scattering
Hair	Practically free	Practically free	Few scattered	Few scattered	Few scattered
Protruding pins	Free	Free	Free	Free	Free

Cuts and tears [1]	Free	1½ inches	1½ inches	3 inches	No limit
Missing skin [2]	None		3 areas totaling not more than ¾ inch.	Tail to hipbones width of feather tract.	No limit
Disjointed bones	1		2		No limit
Broken bones	None (except 1 nonprotruding wing bone if fryer).		1 nonprotruding		No limit
Missing parts	Wingtips		Wingtips, and if ready-to-cook, 2d wing joint and tail.		Wingtips, and if ready-to-cook, wings and tail.
Discolorations: [3]	*Inch*	*Inch*	*Inch*	*Inch*	
Flesh bruises	0	½	½	1½	No limit [4]
Skin bruises	½	¾	¾	1½	No limit
All discolorations	1	1½	1½	3	No limit
Freezer burn	Few small (⅛-inch diameter) pockmarks.		Moderate-dried areas not in excess of ½-inch diameter.		Numerous pockmarks and large dried areas.

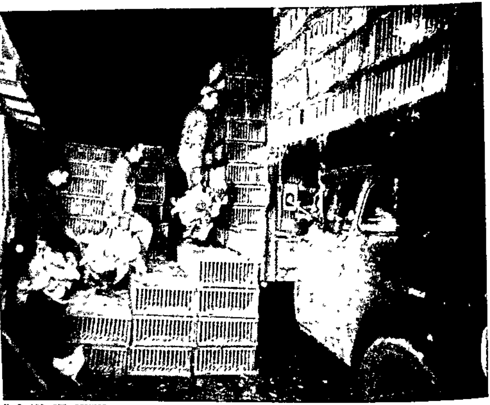
The quality designations specified herein are not applicable to birds possessing any of the following conditions, dirty or bloody head or carcass, dirty feet or vent, fan feathers or neck feathers or garter feathers, or feed in the crop

[1] Total aggregate length of all cuts and tears including incision for removal of the crop or its contents.

[2] Total to be included in total permitted cuts and tears.

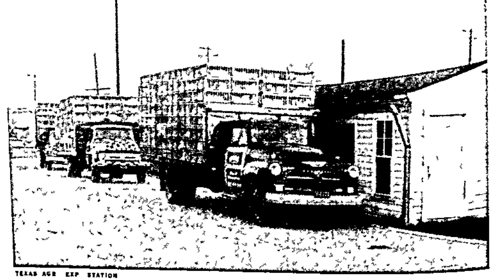
[3] Maximum diameter of aggregate areas of all flesh bruises, skin bruises, and discolorations.

[4] No limit on size and number of areas of discoloration and flesh bruises if such areas do not render any part of the carcass unfit for food.



N. C. AGR. EXT SERVICE

Fig. 11-4. Loading broilers direct from house to truck saves labor.



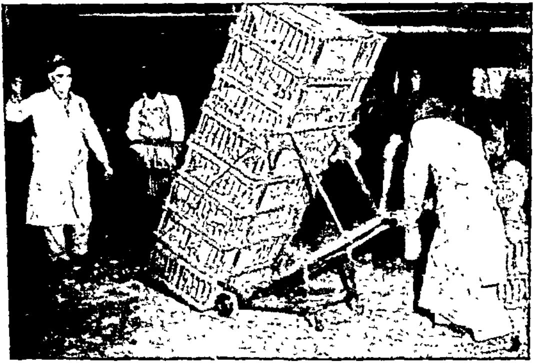
TEXAS AGR EXP STATION

Fig 11-5. Bulk weighing of truck loads of broilers.

The volume marketed influences price. Buyers prefer to buy a truck-load (5,000 to 6,000 broilers) at one stop rather than part of a load at several stops. They save time with fewer stops and the poultry is more uniform when less lots are involved.

TEXAS AGRICULTURAL EXPERIMENT STATION

Fig. 11–6. Unloading broilers direct from truck to slaughtering line.



TEXAS AGRICULTURAL EXPERIMENT STATION

Fig. 11–7. Coop moving device to save labor. Birds may be watered and fed temporarily by attaching feeders and waterers to the coops.

Transportation of live poultry. Coops, 3′ long, 2′ wide, and 1′ high, made of slats or rods, are used for hauling live poultry (Fig. 11–4) Higher coops are used for turkeys and other large fowl. The number hauled per coop may vary from four or five large birds to 15 or 20 small broilers.

Trucks for hauling poultry usually have flat bottoms holding 200–300 coops for as many as 6,000 broilers (Fig. 11–5). Weighing the truck and empty coops before and after filling with poultry, saves labor and reduces the chance of error as contrasted to weighing many small lots.

Catching and hauling at night requires less labor and helps to prevent shrinkage of birds (Fig. 11–4). During short hauls, birds may lose ½ to 1 per cent in live weight, but they may lose as much as 6 per cent in weight during hauls of more than 100 miles in hot weather. Unloading is usually directly from the truck to the slaughter line by movement of coops on a roller-conveyor (Fig. 11–6).

Holding birds in batteries or coops is sometimes necessary if there is an uneven flow of live birds to the processing plant. Birds hauled long distances are also fed and watered a day or so before slaughter to recover from shrinkage (Fig. 11–7). They bleed and pick better if they are not dehydrated.

Processing Poultry

The processing of poultry is the preparation of live poultry for the consumer. It includes slaughtering, evisceration, cooling, cutting-up, and packaging. The size of the business may vary from a single bird for home consumption, to 50,000 or more birds daily in the larger processing plants.

Health regulations. Poultry sold in most cities must meet city health regulations for sanitary processing conditions, health or wholesomeness of the birds slaughtered, and storage of birds until marketed. Poultry sold in interstate commerce must be inspected according to regulations formulated by the United States Department of Health, Education and Welfare; Food and Drug Administration; and administered by the United States Department of Agriculture, Agricultural Marketing Service. Inspection includes: plant sanitary requirements, ante mortem inspection, and post mortem inspection.

Sanitary requirements include: (1) buildings and plant facilities, (2) equipment and utensils, and (3) maintenance of sanitary conditions and precautions against contamination of products.

The building in which processing operations are conducted must be well ventilated and lighted, clean, and free of vermin, dust, flies, and other conditions that would contaminate food products.

Water supply for the processing plant must be ample and potable.

Chlorinated water, used at a level of 20 p.p.m. of chlorine for rinsing of thoroughly washed equipment, helps to keep the bacterial count low in processing poultry. Its use in the chilling tank at a level of 10 to 20 parts per million, also aids in prolonging the shelf life of poultry.

The equipment must be thoroughly cleaned and sanitized after each day's use.

Refuse must be removed from the processing room frequently, stored in barrels in a separate screened storage room, and removed from the premises daily.

Ante mortem inspection is a part of the inspection program. Flocks re-

Table 11–4

POULTRY CONDEMNED IN PROCESS OF INSPECTION *

Disease	Condemned		
	Whenever encountered	If systemic disturbance is evident	Only the affected area or part
Tuberculosis	x		
Lymphomatosis	x		
Botulism	x		
Emaciation	x		
Ornithosis	x		
Newcastle		x	
Fowl typhoid		x	
Infectious laryngetracheitis		x	
Infectious coryza		x	
Chronic respiratory disease		x	
Pullorum disease		x	
Fowl pox		x	
Coccidosis		x	
Blackhead		x	
Tumors, if localized			x
Parasitism			x
Inflammatory processes			x

* Food and Drug Administration.

ceived for slaughter are checked for general health before being placed on the processing line. During the early stages of some diseases, a more accurate examination is possible with live birds than after their slaughter. This is especially true for outbreaks of ornithosis and fowl typhoid.

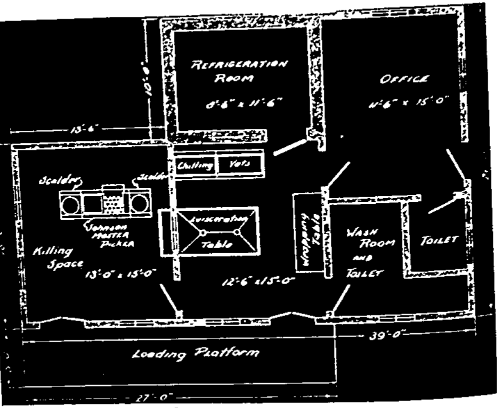
Post mortem inspection is made at the time of evisceration, as soon as the birds' entrails are exposed and before they are removed and the giblets reclaimed. The inspector examines both the external and internal surface of each carcass. He observes lungs, kidneys, air sacs, and visceral organs. The liver and spleen are also examined.

Condemned poultry includes any carcass or part thereof found to be unsound, unwholesome, or otherwise unfit for human consumption. (Table 11–4).

Poultry Processing Plant Design

The designs of processing plants vary widely depending on type of building, size of enterprise and type of equipment used (Figs. 11–8 and 9). It is essential that slaughtering, scalding, and picking be done in one or more rooms, separate from those used for eviscerating, cooling, and packaging. Otherwise, dust and odors from the slaughtering room may contaminate poultry in the latter stages of processing.

The inspector's station is located near the front of the eviscerating line. He must examine the carcass and its parts as soon as it has been opened and



COURTESY THE GORDON JOHNSON COMPANY

Fig. 11–8. Suggested plan for a small poultry eviscerating plant. Note that the eviscerating and wrapping room is separate from the killing room.

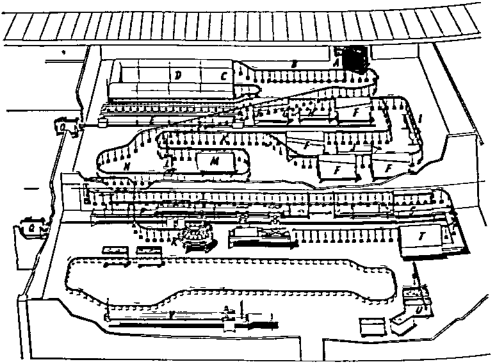


Fig. 11–9. Diagram of a large dressing plant.

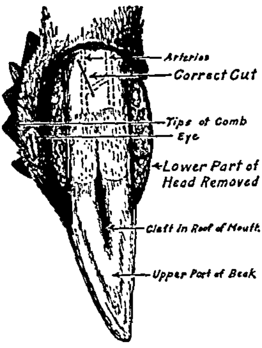


Fig. 11–10. Bleeding of poultry is accomplished by inserting a special knife through the mouth and severing the blood vessels as indicated. (Drawing by Noel Hall.)

Fig. 11–11. Holding bird for slaughter by cutting the jugular vein.

the parts exposed. If the carcass is to be condemned, it is removed from the line before further eviscerating and processing steps are taken.

Slaughtering. Poultry is generally hung on shackles and slaughtered by bleeding (Fig. 11–6). The jugular vein (Fig. 11–10) is cut from the outside with a sharp knife (Fig. 11–11), by holding the head between the thumb and forefinger with the left hand, and making a cut through the skin and jugular vein at the juncture of head and neck.

Immobilization is sometimes carried out before birds are bled to reduce struggling. This may be done by passing the birds through a carbon dioxide chamber; by touching an electrically charged bleeding knife to its comb; or by injecting or feeding a tranquilizer. Immobilization is most useful for

Table 11–5

MOISTURE-VAPOR PROOF, TRANSPARENT, SHRINKABLE BAGS FOR READY-TO-COOK WHOLE CHICKENS, WATERFOWL AND TURKEYS

Whole birds Weight	Size of bag	Approximate cost per bag
1.5 — 2.5 lbs.	7" × 14"	2-3 cents
2.5 — 4.5 lbs.	8" × 15"	2-3
5-6 lbs.	10" × 16"	3-4
7-8 lbs.	12" × 18"	4-5
9-12 lbs.	12" × 20"	7-8
14-18 lbs.	16" × 24"	12-13
22-30 lbs.	20" × 28"	14-15

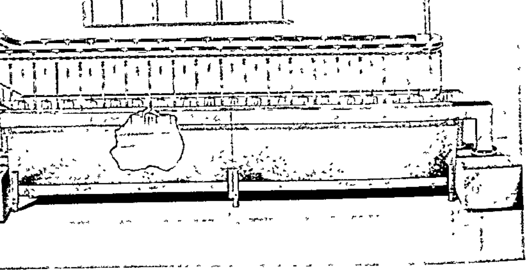


Fig. 11–12. Tank used for scalding of poultry.

slaughtering turkeys or other large birds which may struggle, causing broken bones or bruises.

The time required for a bird to expire through bleeding varies from less than a minute for small birds to more than two minutes for large turkeys. Blood constitutes about 4 per cent of the live weight of poultry (Table 11–6). A bird which has been poorly bled will have a pink or reddish appearance after feather removal. Birds with fever (systemic disturbance) such as acute cholera or blackhead may not bleed well. These birds should be condemned before slaughter.

Dry picking. Feathers may be removed through dry picking, in which process the bird is held against a machine that removes the feathers and collects them in a bag. However, the method is too slow for profitable operation. Its advantages are a neat carcass and easy reclamation of feathers for marketing.

Wet picking. The most widely used method to remove feathers from poultry is through wet picking. The process may be supplemented with wax picking. The birds are immersed in hot water and the feathers are removed by hand or mechanical pickers. Wet picking is faster than dry picking because scalding loosens the feathers. However, if the feathers are to be recovered and processed, the method is more costly; but the saving in labor more than compensates for the extra cost of drying feathers.

Feathers account for 5 to 8 per cent of the live weight of poultry (Table 11–6). Females have more plumage than males, and waterfowl, more than chickens.

Scalding is the immersion and agitation of the slaughtered birds for 30 to 60 seconds in water with a temperature of 126°–180° F. Hot water reaches the base of feathers and loosens them by relaxing the muscles around the feather follicles. The birds should be scalded as soon as they are dead, or the feathers have a tendency to "set" making them difficult to remove. If scalding time is prolonged, the meat may also toughen.

When scalding broilers, high temperatures are used for short periods, but for old birds, the temperature is usually higher and the time longer. The scalding time and temperature is usually the same for chickens and turkeys,

Table 11–6

ESTIMATED YIELDS OF INEDIBLE PRODUCTS FROM POULTRY PROCESSING *

Items	Raw offal		Processed offal	
	Percentage of live weight	Pounds per 1000 broilers	Percentage of uncooked offal weight	Pounds per 1000 3½ lb. birds
Heads	3.0	105		
Feet	5.0	175		
Viscera	10.5	368		
Free moisture **	2.0	70		
Total offal	20.5	718		
Feathers (dry)	7.6	266		
Free moisture **	3.8	133		
Wet feathers	11.4	399		
Blood	3.7	130		
Dry tankage	...	...	27.0	194
Grease	...	...	4.5	32
Blood meal	...	...	12.5	15
Feather tankage	...	...	25.0	100

* Kahle and Gray.
** *Picked up in processing.*

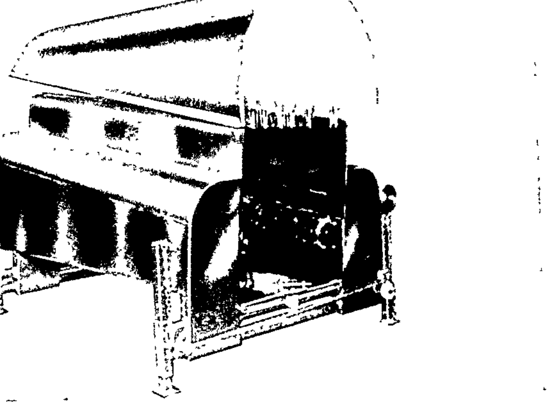
but waterfowl require longer time and higher temperatures. Surfactants are sometimes added to the scalding tank to reduce surface tension of feathers and to aid water penetration to their base. The solution is especially useful for scalding waterfowl.

Longer tanks are used to increase the time of scalding. The shackled birds are moved up and through the tank (Fig. 11–12), or the conveyor line is operated at a slower rate. Agitation of birds in the tank is completed by equipment which rolls them over, pushes them up or down, and forces streams of water against the carcass.

Hard scalding of poultry is in water at 160–180° F. It facilitates feather removal but also removes the thin epidermal layer of the skin. Hard scalded birds darken quickly when exposed to the air. This method is frequently used for picking waterfowl. The shelf life (keeping time) of hard scalded poultry is not as long as birds scalded at lower temperatures.

Sub-scalding is the immersion of poultry in water at 138°–140° F. for 30 to 75 seconds. This scalding procedure removes part of the epidermal layer of the skin and darkens it unless the surface is kept moist. When this method is used, almost all of the feathers including pin feathers may be removed by mechanical pickers (Fig. 11–13). The appearance of skin surface is less important when poultry is cut-up or frozen. Since more poultry is being sold via this packaging, the sub-scalding method is gaining popularity.

Semi-scalding of birds is in water at 123°–130° F. depending on age of the bird and length of immersion time. This method gives the carcass a



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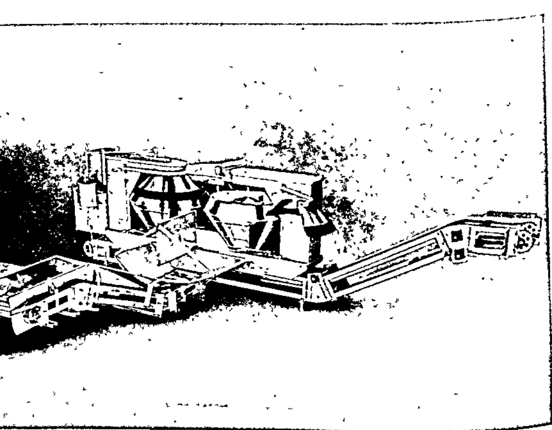

BARKER POULTRY EQUIPMENT COMPANY OTTUMWA, IOWA

Fig. 11–13. Types of picking machines. Top. Drum picker. Bottom. Dual drum cycloma pickers.

wholesome appearance, but requires additional hand labor to remove remaining feathers and pin feathers after use of the mechanical picker.

Mechanical picking is used widely in the wet picking method (Fig. 11–13). The feathers are beaten off with rubber fingers attached on drums. The birds may be held against a picker, put into a centrifugal picker, or pulled through one or more double drum pickers while on the shackles.

Wing stripping is generally used in the picking line to remove large wing feathers and main tail feathers. The wing or tail feathers are held against two rollers and pulled through, as wet clothing is pulled between rollers to remove the water.

Pinning is done by hand after the birds have passed through the last mechanical picker, in order to remove any feathers that have been missed.

Singeing follows the final pinning operation in order to remove the hairlike feathers found on some birds, especially old ones. A gas flame envelops the birds momentarily as they are singed on the shackle line. In small operations, they are hand singed (Fig. 11–15).

Wax picking. After scalding and preliminary picking on a mechanical picker, birds are sometimes dipped in

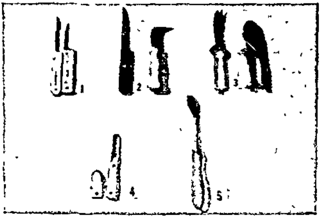

Fig. 11–14. Some poultry processing tools. 1. Sticking knives. 2. Boning and carcass splitting knives. 3. Shears for removing head and feet. 4. Pinning tools. 5. Lung or kidney remover.

Fig. 11–15. Singeing bird with a hand singer.

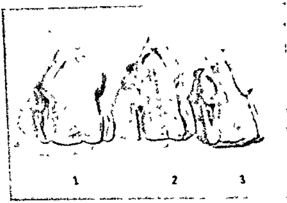

Fig. 11–16. Whole eviscerated and trussed birds. 1. Grade A, 2. Grade B, 3. Grade C.

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Fig. 11–17. Broiler and fryers prepared for cooking.

melted wax (about 130° F.). The dip is allowed to solidify on the bird, and the coating is removed by hand or by a mechanical picker. The wax removes small feathers, pin feathers, and hairlike feathers when it is peeled off, leaving a carcass of wholesome appearance and eliminating the singeing process. The wax becomes contaminated, and it must be sterilized and the sediment removed between each use. It may be re-claimed by melting and filtering out feathers. Wax picking is used most frequently for waterfowl, because it removes down feathers, but it is too slow and costly for removal of chicken and turkey feathers.

Evisceration is the removal of the head, feet, oil gland, and viscera, with recovery of the heart, liver, and gizzard. The procedure may vary, particularly in small operations, depending on whether the carcass is to be sold whole (Fig. 11–16), in halves, quarters (Fig. 11–17), or cut-up (Fig. 11–18).

The crop, gullet, and trachea are loosened by a longitudinal cut in the neck skin and pulled loose with the fingers. *The oil (preen) gland* at the base of the tail is removed by a "scooped-out" cut through the skin. *The large intestine* is loosened by a cut around the anal opening. *The head* is cut off at its juncture with the neck. *The neck skin* is slit down the back, and after removal of the crop, gullet, and trachea, it is severed at its junction with the body and kept as an edible part of the carcass. *The feet* are cut off at the hock joint.

Broilers to be sold as halves or quarters may be split down the back and

the sides, then pulled apart for exposure of viscera and their removal. Birds to be sold whole will be cut around the anal opening with the cut extended along the abdominal wall toward the rear of the keel to permit insertion of the hand for removal of viscera, or a horizontal cut will be made at the rear of the keel. Fowl which are to be cut-up may have the legs, wings, and neck cut off. The bird is cut along each side from the rear of the keel to the sternum and the breast pushed forward to expose the viscera.

The lungs are removed by hand, a scraper, or a vacuum. *The kidneys* may or may not be removed. *The giblets* (heart, liver, and gizzard) are recovered. *The gall bladder* is removed from the liver, with care to avoid puncture, and it is discarded. The gizzard is opened, the contents are washed out, and the lining is removed. The heart is freed of blood and adhering blood vessels. Giblets make up 4.5 to 13 per cent of the ready-to-cook weight of different species (Table 8–Appendix).

Evisceration loss, including blood and feathers from live bird to the dressed product, varies from 20 per cent in large turkeys to 35 per cent in small broilers (Table 7–Appendix). To determine equivalent values of live and ready-for-the-oven poultry, exclusive of processing and packaging charges, subtract the per cent of shrinkage from 100 per cent. The sum will be the edible percentage. Divide the live price per pound by the edible percentage and the result will be the equivalent market price. For example, what is the ready-for-the-oven value per pound when the live bird price is 20 cents per pound and the shrinkage 25 per cent, no charge being made for processing and packaging? 100 minus 25 equals 75 per cent and 20 divided by 75 equals 26.6 cents. The processing and packaging costs amount to about 7 or 8 cents per pound (Chapter 12).

Post mortem inspection, if done, is made during evisceration, as soon as the viscera are exposed. The viscera may be left attached to the bird as it is suspended from the shackle, or the viscera may be loosened and held beneath the bird in a pan until the examination is completed (Fig. 11–19).

The speed with which birds may be examined in line operations varies from about 300 to 1,500 per hour, depending upon their age and condition. Line operations at the point of inspection may be slowed down if the birds are routed on two or more lines from the point of viscera exposure and examination by an inspector.

Cooling. Poultry which has been cooled or frozen before evisceration may be damaged by unpleasant visceral odors and bile staining. Immediate evisceration after slaughtering eliminates this effect. In addition, birds which are cooled quickly after slaughtering and evisceration retain their fresh composition longer and cool more rapidly than birds cooled before evisceration.

Air cooling with a blast of cold air in a chill room is satisfactory, but causes a loss in weight and a darkening of the carcass.

Ice-water cooling in tanks is a common method (Fig. 11–20). The birds may gain as much as 3 to 8 per cent in weight during the first six to eight hours and more slowly after that. The cooling should be lower than 40° F. at all times. Birds should be cooled to an internal temperature of 40° F. or less within 24 hours. The slush ice water should be changed if birds are to

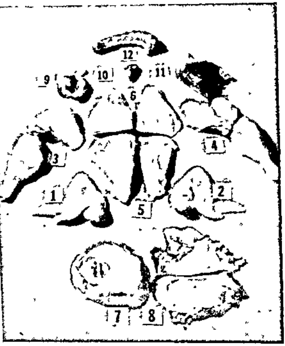


Fig. 11–18. Cut-up poultry. 1 and 2 wings. 3 and 4 legs and thighs. 5 and 6 breast. 7 and 8 back. 9 gizzard. 10 heart. 11 liver. 12 neck.

remain in the tank longer than 24 hours. Circulation of ice water in the cooling tank is by means of a pump or bubbling air which shortens the cooling time.

Antibiotic use in the cooling tanks prolongs the shelf life of poultry processed under sanitary conditions and held at low temperatures. Broad spectrum antibiotics such as chlortetracycline or oxytetracycline are most satisfactory for this purpose. They are used at levels of 5 to 15 p.p.m. in the chill tanks.

Grading poultry. Factors considered in grading ready-for-the-oven poultry include: conformation (Fig. 11–16), fleshing, pin feathers, cuts and tears, discolorations, and freezer burn (Fig. 11–22). The standards of quality used in formulating the three grades of poultry are summarized in Table 11–3.

Freezer burn is shown by dehydrated areas on the skin (Fig. 11–22). It develops on unpackaged or poorly packaged birds held in cold storage longer than two or three weeks.

Cut-up poultry. Cut-up poultry is increasing in popularity. The carcass may be halved, quartered, or cut into parts. Frozen turkeys are sometimes cut into steaks. Purchasers may purchase the parts they prefer. The percentage distribution for parts of poultry species is given in Table 8, Appendix.

The inexpensive parts (necks, backs, and wings) are often the best buys when purchasing chicken or turkey parts (Fig. 11–26). It may appear that these parts have considerable bone waste, but avian bones are light, and on a weight basis constitute only 15 to 20 per cent of the dressed carcass weight.

Packing poultry: Poultry is packaged for convenience in handling, protection from dust and dirt, and for reduction in moisture loss and preservation of quality. The giblets, especially the liver, are usually wrapped and inserted in the body cavity of whole bird carcasses. The neck is also inserted into the body cavity.

Ice packing is generally used for wholesale transportation of chilled poultry. From 25 to 50 eviscerated broilers are packed in paper-lined, wire-bound wooden boxes with layers of crushed ice between the birds. Ice-packed poultry is held in refrigerators and transported to markets in refrigerated trucks.

Tray or box packaging of cut-up poultry or poultry parts is frequently em-

ployed (Fig. 11–25). In tray packing, the tray and parts are covered with transparent cellophane for short-time, nonfrozen display in refrigerator cases. Aluminum foil, cellophane, laminated paper, wax paper, and butcher paper are used for packaging poultry.

Fig. 11–19. Inspecting broilers for wholesomeness. The birds have been split down the back. Each bird's viscera is in the pan below it.

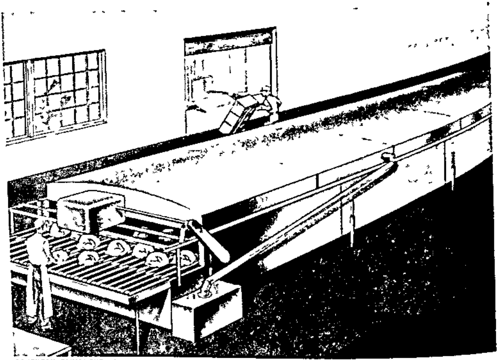
Surface coatings applied as a dip or spray show promise of preventing dehydration and loss of color, extending the keeping time since they fit skin-tight over the entire surface, and holding out moisture and air. A polysaccharide made from seaweed is edible as a surface coating material.

Moisture-vapor proof, shrinkable, transparent bags are used for packaging roasting chickens, waterfowl and turkeys, especially when they are to be held in cold storage longer than a month. The carcass is inserted in the bag with the wings pressed tightly against the body (Fig. 11–23), and with the legs held together by forcing them through an opening made around the vent (Fig. 11–24), or by tying them to the tail bone. Part of the air is drawn out by means of a vacuum tube, and the package is then twisted for sealing and is fastened with a band or clip. The bag is dipped for a second in water near the boiling point for shrinkage and to make it stick skin-tight to the carcass. Bag sizes and prices for different weight chickens and turkeys are given in Table 11–5. Since bags are thin and frozen carcasses have sharp wing tips and hock joints, it is advisable to provide protection against puncture by further packaging in wire-bound boxes or cartons.

Preservation of Poultry Meat

Poultry meat is a highly perishable product. It keeps for only two or three days in household refrigerators (45° F). Poultry meat which is to be held longer, should be kept near freezing, and if held more than a week, it should be preserved by *freezing, canning, pre-cooked-frozen,* or possibly by *irradiation.*

Freezing poultry. Poultry may be preserved by freezing at −20° to −40° F. The lower the temperature, the whiter the appearance of the carcass and the less danger of bone darkening in young poultry. During the freezing process, the air should be allowed to circulate around each package. Blast air freezing reduces the freezing time and increases the freezing capacity of the freezer.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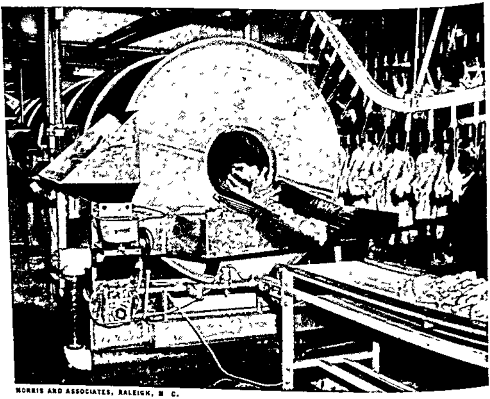
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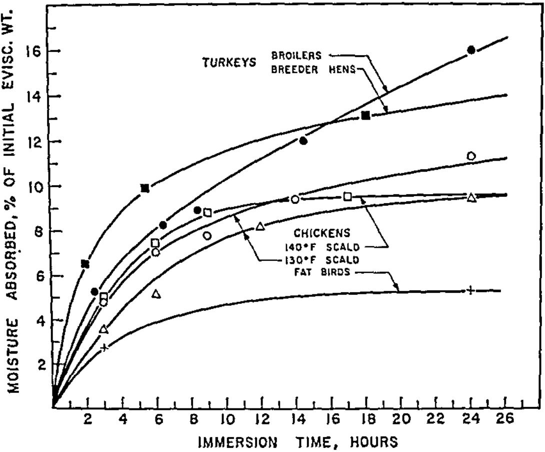
Fig. 11–20 Types of chilling. Top—Automatic weighing, chilling and boxing poultry. Bottom—A rotary chiller.



LENTZ AND ROOKS

Fig. 11–21. Water absorption of eviscerated poultry during immersion cooling in ice water.

Fig. 11–22. Turkeys showing various degrees of freezer burn during 20 months storage at 0° F.:

1. Unwrapped. Much dehydration.
2. Wrapped in butcher paper. Much dehydration.
3. Wrapped in 2 mil. polyethylene. Slight dehydration.

Fig. 11–23. Rooster in moisture-vapor proof bag.

Fig. 11–24. A trussed rooster.

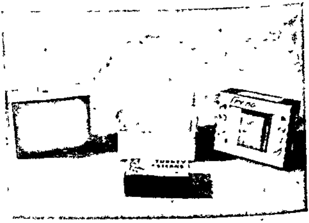


Fig. 11–25. Boxes for cut-up poultry.

Poultry should be held six hours or longer between the time of slaughtering and freezing to avoid toughness. The frozen bird should be defrosted before cooking or it will be tough. Immersion freezing of birds in a brine, glycol, or acetone solution also shortens the freezing time. A leak-proof package is necessary for immersion freezing.

Frozen storage time of poultry may be as long as a year for chickens or six months for turkeys, ducks and geese, without the development of rancidity if they are packaged to keep out air.

Canning poultry. Poultry may be preserved by canning. The temperature and time used in canning to insure preservation destroys much of the chicken flavor. The pieces or eviscerated carcasses are placed in jars or cans; the lids are left loose; and the containers are heated in pressure cookers at about 10 pounds pressure (240° F.) for 55 minutes with pint (No. 2) containers, 75 minutes for quart (No. 3) containers, and longer for larger containers. The lids should be tightened as soon as removed from the cooker; canned poultry should be stored in a cool place.

Pre-cooked frozen poultry. Some poultry is cooked and frozen and then heated just before use. The original cooking temperature and time need not be as great for pre-cooked poultry which is to be frozen. The cooking time before use of pre-cooked poultry is considerably shorter than for poultry which has not been cooked and frozen.

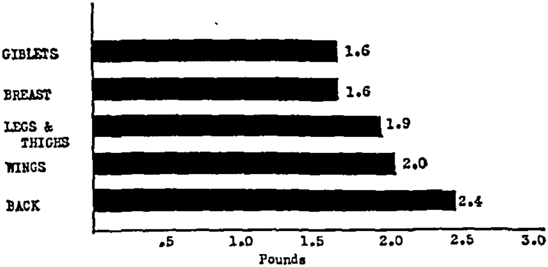


Fig. 11–26. Number of pounds of cut-up parts of poultry required to produce 1 lb. cooked, edible chicken meat.

Irradiation of poultry. Gamma or beta ray irradiation may be used to sterilize poultry meat in nonmetal containers so that it will keep without canning or freezing. The rays penetrate the package and meat killing microorganisms without much change in the properties of the product. The process is too costly for general use at the present time.

Dehydration. Poultry and other meats may be dehydrated for preservation in much the same way as apples and other food products. The process is costly and does not give a palatable product. It may find use in military field or outer-space rations where bulk and weight are factors.

Smoking poultry. Ready-to-cook whole birds are impregnated with a curing solution by puncturing the skin at spots on the wings, breast, and thighs; and then soaking the birds for one to three days at 40° F. in a curing or pickling solution similar to that used for curing hams. A satisfactory mixture consists of 75 pounds salt, 20 pounds of sugar, 12.5 pounds of commercial curing mixture, and 50 gallons of water. After soaking, the birds are removed, wiped dry, and smoked for six hours at 160° F. with hickory-oak sawdust or green apple wood. The birds should be aged for a week at 40–45° F. before use.

During the smoking process, the white meat becomes pinkish and the dark meat becomes red. Smoking adds flavor and prolongs keeping time; however, it does not afford complete preservation and it is not a substitute for cooking. Smoked poultry should be soaked over night to remove some of the curing brine and then roasted in the usual manner.

Determining Quality of Poultry Meat

Visual estimation of quality has been summarized in Table 11–3. Tenderness, juiciness, flavor, bacteria and mold surface counts, free ammonia, and iodine number, are additional measures of poultry meat quality.

Tenderness sampling may be made by a taste panel chewing test. At the same time, the panel may rate the samples for juiciness and flavor. This is known as subjective measurement of quality. Tenderness may also be measured by a shear press or penetrometer.

Juiciness may be estimated by a taste panel in which two or more samples are compared with a control. It may also be measured by use of the carver press, which actually presses out fluid from a known weight of sample.

Flavor is measured by a taste panel at the present time. However, chemical measures of flavor (volatile compounds and minerals) are being developed.

Bacteria and mold surface counts measure the sanitary conditions under which poultry is processed. Analyses may be made by washing a given surface (usually 1 sq. cm.) with a swab or by washing a given weight piece or carcass with a given amount of sterile saline and analyzing the swab or wash water for bacteria and mold counts. Samples containing 10 million bacteria per gram of weight or sq. cm. of surface, are spoiled or very near the spoilage stage.

Free ammonia determination gives a measure of protein tissue breakdown. Poultry meat samples will usually develop an "off" odor before there is any noticeable increase in free ammonia.

Iodine number is used as a measure of fat breakdown. This results in an increased number of unsaturated bonds and an increased iodine fixation (iodine number).

Peroxide content of fat may be used as a measure of its stability.

Uses of Poultry Meat

General uses. Poultry meat may be fried, roasted, barbecued, stewed, or broiled. It may also be used in sandwiches, salads, and soups.

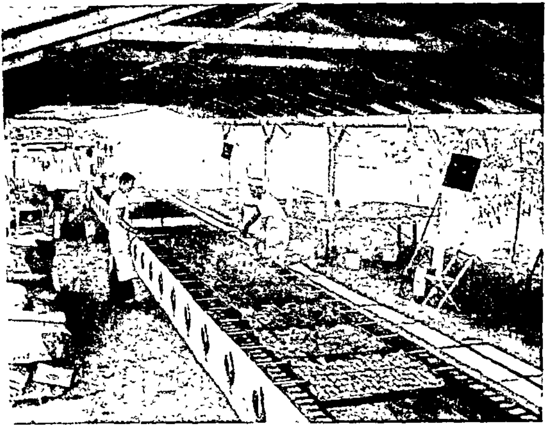
Poultry specialty products. Poultry meat is used in chicken and turkey pies, in sausages, chicken sticks, creamed chicken, chicken à la king, Chicken chop suey, soups, and broths. The meat is usually obtained from the less desirable pieces such as necks, wings, backs, and the carcasses after the birds have been de-boned for chicken or turkey rolls.

Space does not permit a listing of the recipes for making chicken and other products from poultry meat. Recipes may be found in household cook books or obtained from the Poultry and Egg National Board, Chicago, Illinois.

Chicken and turkey frozen pies and dinners have become important specialty items in recent years.

Turkey and chicken sandwich rolls are made from de-boned poultry. The neck, back, wings, and bony carcass remaining after de-boning may be used for making soup and other items if diced or shredded poultry meat is to be used.

Barbecued chicken. This special method of preparing chicken has become popular in recent years. The chicken is usually cooked over an open



OHIO POULTRY COUNCIL

Fig. 11–27. Barbecuing chicken at the Ohio State Fair.

charcoal pit and kept from drying out or burning by frequent spraying and basting with a barbeque sauce. Halves of chickens weighing 2.0 to 2.5 pounds are the most suitable for barbecuing. The time required to cook birds of this weight thoroughly by the pit method, is 45 minutes to an hour, with turning every five minutes.

Barbecue sauce is composed of various ingredients, depending on individual taste. The essential ingredients for five chickens (serving ten people) are: ½ pint water, 1 pint vinegar, ½ pound butter or ½ pint cooking oil. Additional flavoring may be added. Details for barbecuing chicken, suggested menus, quantities needed, barbecue sauce recipes, and other information may be obtained from the poultry departments of most land grant colleges and from the Poultry and Egg National Board.

Future uses of poultry meat. The future use of poultry meat will depend on its price in comparison with competitive meats such as beef and pork. (Table 10, Appendix).

Research is needed to find new uses and ways of serving poultry meats. They are highly digestible, low in cholesterol, and have a good distribution of vitamins and amino acids.

Education is needed on the purchase of quality poultry (*Fig. 11–26*), and ways of cooking, holding, and serving.

Advertising of poultry meats is necessary so that it may compete with other meat products.

The Poultry and Egg National Board, the National Broiler Council, and the National Turkey Federation are sponsoring research, supplying educational material, and doing a modest amount of advertising poultry meats.

Inedible Poultry By-Products

The blood, feathers, viscera, head, and feet are generally disposed of as inedible by-products. They constitute from 20 to 35 per cent live weight of the birds. There is usually little or no income from these products. The feathers are generally scattered on land as fertilizer. The blood is washed down the drain and the offal hauled to swine farms. Larger processing plants find that it pays to process the materials for animal feeding purposes.

Feathers, especially the down from waterfowl, make excellent insulation. They are used in aviator garments, insulation board, fiber for cloth production, feather dusters, and ornaments.

Feather meal, a rich protein feed (Table 1, Appendix), is made by cooking feathers under pressure, then drying and grinding them to powder. Feather meal may replace as much as five pounds of other animal protein feeds per 100 pounds of ration without lowering its value.

Poultry offal. The head, feet, intestinal tract, and lungs are the offal. They are usually recovered in processing plants and stored in metal barrels. In the larger processing plants, the offal is usually sold to rendering plants for about $0.75 to $1.50 per barrel. It may be cooked, dried, ground, and used as an ingredient in pet foods. Or, it may be combined with offal from cattle and swine and made into tankage or meat scrap.

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Chapter 12

Poultry Farm Management

POULTRY FARM MANAGEMENT is the application of principles and practices for the economical production and marketing of poultry products (Table 12–1). The economics of poultry production and marketing include investment, expenses, and income. The profit for one's labor in production is sometimes referred to as *labor income.*

The Poultry Outlook

A study of demands for poultry products, trends in production, and the market situation, is useful for expanding or curtailing poultry production or marketing activities.

Demand for products. The demand for poultry products promises to continue at a favorable rate (Chapter 1). Poultry meat and eggs are highly nutritious and relatively cheap food products (Table 12–1).

Production trends. The trends in poultry production should be followed closely and analyzed for possible future influence in one's business. The present trends include area production (Table 1–4) and (Fig. 12–1); specialization of broilers or replacement pullet production; year-round rather than seasonal production; increased size of enterprises and use of labor saving equipment.

The market outlook. Market information is useful in planning the development of a poultry enterprise or expansion or curtailment of one already established. It is seldom advisable to halt operation of an enterprise until better prices are in prospect. The investment interest, taxes, depreciation, and other fixed costs continue whether the facilities are in use or not. It is difficult to predict accurately when prices will be more favorable.

Indicators of future markets include: (1) Industrial employment. There is a close relationship between employment and farm prices. Wage earners constitute a majority of the consumers. (2) Production of competitive products. As an example, a surplus of hogs will send the price of pork down and keep the price of poultry meat low. (3) Chick and poult placement reports. These indicate the broiler supply eight to ten weeks later and the turkey supply four to six months later. (4) Cold storage holdings. Seasonal production and surplus cold storage holdings of poultry meat and eggs are not as great as they were; however, a large cold storage holding of turkeys will hold down the price of freshly slaughtered turkeys. (5) Egg-feed ratio. Half of the total

Table 12–1

POULTRY PRODUCTION—CONSUMPTION—PRICE SUMMARY 1937–1958 (U. S. D. A.)

Year	No. of Hens & Pullets Jan. 1	Farm Egg Production: Number Produced	Farm Egg Production: Gross Income	Gross Income from Farm Chickens	Eggs Consumed per Capita	Chicken Consumed per Capita	Avg. Farm Egg Price per Doz.	Avg Price per lb. All Chickens	Turkeys: Number Raised	Turkeys: Gross Income	Broilers: Number Raised	Broilers: Gross Income
	Millions	Million Dozens	Million Dollars	Million Dollars	Number	Ready-to-Cook wt.	Cents	Cents	Millions	Million Dollars	Millions	Million Dollars
1937	380	3130	652	343	308	13.6	21.3	16.7	26	68	68	42
1938	353	3113	616	300	310	12.7	20.3	15.4	27	68	82	46
1939	376	3237	551	296	313	14.1	17.4	13.8	34	72	106	52
1940	393	3309	582	286	319	14.1	18.0	13.9	34	80	143	72
1941	381	3491	808	368	311	15.4	23.5	16.3	53	101	192	103
1942	428	4051	1197	510	318	17.7	30 0	19.8	33	147	228	155
1943	489	4546	1668	852	347	23.0	37.1	25.3	32	162	285	238
1944	524	4878	1571	780	354	20.4	32.5	24.9	35	199	274	235
1945	474	4685	1751	852	402	21.6	37.7	27.0	43	245	366	327
1946.	473	4664	1743	814	379	19.4	37.6	29.0	40	273	292	289
1947.	431	4615	2078	727	383	18.1	45.3	28.2	34	236	310	302
1948.	418	4575	2145	711	389	18.3	47.2	32.3	32	263	370	405
1949	399	4680	2103	644	383	19.6	45.2	26.6	41	267	513	443
1950..	434	4913	1773	537	389	20.6	36.3	24.9	44	270	631	533
1951	399	4838	2297	580	392	21.7	47.8	27.1	53	351	789	689
1952 .	397	4839	2002	473	390	22.1	41.6	26.2	62	356	861	756
1953 .	373	4824	2289	453	379	21.9	47.7	25.3	60	340	947	786
1954 .	371	4911	1795	333	376	22.8	36.6	21.1	68	335	1048	747
1955.. .	369	4957	1994	310	371	21.4	38.9	23.4	66	329	1092	844
1956 ...	360	5091	1961	262	368	24.6	38.7	18.8	77	342	1344	838
1957....	369	5039	1768	194	358	25.6	35.2	18.0	81	318	1452	887
1958.....	371	5057	1935	203	348	28.5	38.3	17.7	78	317	1660	1003

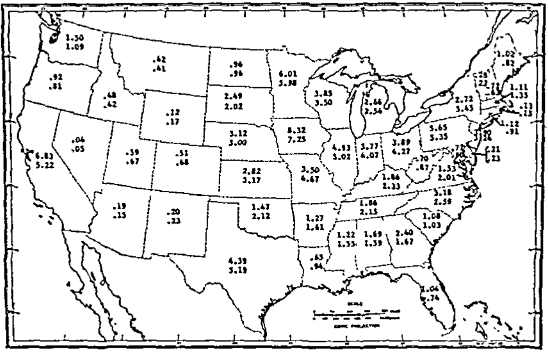


Fig. 12–1. Percentage distribution by states of the layers on farms (top figures for 1959 and bottom figures for 1951).

cost to produce eggs is for feed. When feed grains are high and egg prices are low, the profit in egg production is slight. When the reverse is true, there is a greater profit in egg production. The relationship between egg price and feed cost is the egg-feed ratio (Fig. 12–2).

Location of the Poultry Enterprise

In the establishment of a poultry enterprise, the markets, land, and transportation should be considered.

Nearness to market. Nearness to market insures a better price for the product. However, this factor must be balanced against the higher cost of land and labor.

Land. Land requirements for poultry enterprises have decreased with the trend toward confinement production of poultry (Fig. 12–3). Consideration should be given to the location of the poultry houses with respect to other buildings, access to roads, space for future expansion, and landscaping. Sufficient distance should be provided from dwellings or business establishments to avoid possible complaints from odors, noises, etc.

Transportation. Cost of transportation of feed and other supplies to the farm as well as eggs and poultry meat to market should be considered when establishing a poultry enterprise.

Utilities. The modern poultry farm should have access to water, electricity, and an economical source of fuel.

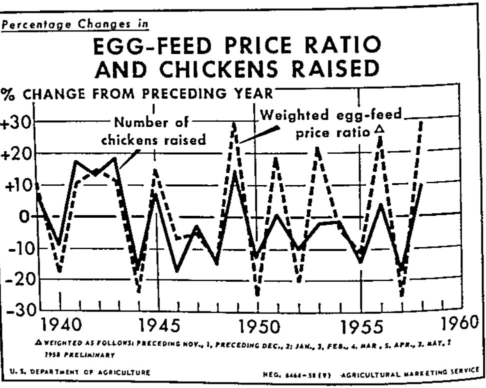


Fig. 12–2. Relation of the Egg-Feed Ratio to the Number of Chickens Raised in the United States, 1939–58.

Poultry Enterprise Investment

The poultry enterprise investment will vary with the type of business, the location and size, and the quality and amount of facilities provided.

Type of business. Table 12–2 gives the comparative investment for four poultry enterprises. Poultrymen sometimes fail to include overhead when calculating the cost of production. In the calculation shown, the overhead amounts to about 14 per cent of the total cost of commercial egg production.

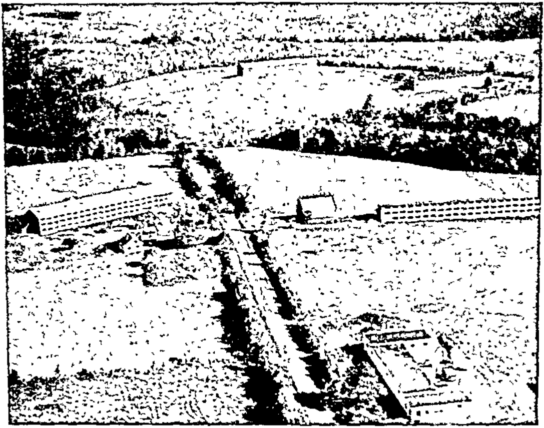
Size of Enterprise

As the poultry enterprise increases in size, the total cost per layer, broiler, or chick declines.

Facilities provided. The cost of facilities for poultry production will vary from about one to ten dollars per bird depending on use of building, type of construction, floor, insulation, ventilation, heat supply, feeding and watering equipment, and pit cleaner (Tables 7–9 and 12–3).

Feed Cost

The greatest cost item for poultry production is feed, ranging from slightly more than 50 per cent for breeding stock to nearly 70 per cent for broiler



ARBOR ACRES FARM INC., SKOWHEGAN, ME. BRANCH

Fig. 12-3. A well planned poultry breeding farm.

production. The composition of the ration (Table 12–4), quantity purchased, and delivery and storage influences feed cost (Table 12–5). For example, the difference in price per single bag and bulk delivery is $10.00 per ton. Feed cost alone may account for profit or loss in the poultry industry.

Table 12–2

POULTRY INVESTMENT AND COSTS FOR FOUR TYPES OF PRODUCTION ENTERPRISES *

Number of Birds per Year	Type of Business			
	Market eggs	Hatching eggs	Broilers	Roasters
	2,592	2,392 layers 200 males	40,000 (4 crops)	30,000 (3 crops)
Cost items				
Overhead **	$ 2,250	$ 2,250	$ 2,250	$ 2,250
Chicks	1,200	828	6,000	4,500
Fuel and litter	120	132	1,600	1,200
Feed	13,289	15,375	20,084	21,601
Blood testing		154		
Miscellaneous	1,000	1,000	1,000	1,000
	$17,859	$19,739	$30,934	$30,551

* Jeffrey. Mass. 1954.

** Overhead

Depreciation of building $16,000 @ 5%	$ 800
Depreciation on equipment $3,000 @ 10%	300
Taxes	350
Interest on investment $20,000 @ 4%	800
Total	$2,250

Table 12–3

COMPARISON OF AVERAGE WITH HIGH AND LOW LABOR INCOME FLOCKS*

Jan. 1 to Dec. 31 Record	Average of 20 Flocks	5-High-Labor Income Flocks	5-Low-Labor Income Flocks
Average size of flock	449	528	393
Average eggs per hen	216	232	197
Percent mortality	15 8	12.0	14.0
Flock investment (birds, housing)	$2,052 45	$2,064.57	$2,502.50
a. Investment per hen	$ 4.57	$ 3.91	$ 6.29
Gross flock income	$1,800.58	$2,560.34	$1,270.76
a. Gross income per hen	$ 4 01	$ 4.85	$ 3 19
Total flock expense	$1,373.65	$1,671.85	$1,215 40
a. Expense per hen	$ 3.05	$ 3.17	$ 3.05
Pounds of feed per hen	98.3	97 6	102.0
a. Pounds of feed per dozen eggs	5 5	5.0	6.2
Average price received per dozen	$ .31	$ .31	$ .30
Average cost per dozen	$ .27	$ .24	$ .31
Feed cost per hen	$ 2.78	$ 2.82	$ 2.88
Flock profit and interest earned	$ 426.93	$ 888.49	$ 55.36
a. Labor and interest per hen	$ .95	$ 1.68	$ .14
Interest charge at 6 per cent	$ 113.65	$ 123.86	$ 150.14
Net income except labor	$ 313 28	$ 764.63	—$ 94.78
a. Net income per hen	$ .70	$ 1 45	—$ .24
b. Net income per hour	$ .70	$ 1.33	—$ .29
c. Hours per hen	1.0	1.1	.82
Source of receipts per hen.			
a. Market eggs	$ 5 27	$ 5.86	$ 4.35
b. Market poultry	$ .56	$ .48	$ .67
c. Hatching eggs or breeding stock	$ .05	$ .00	$ .18
Average cost of ration per 100 pounds	$ 2.82	$ 2.89	$ 2.83
Return per 100 pounds of feed used	$ 1.44	$ 1 72	$ 1.11
Cost of mature pullet replacement (per dozen eggs)	$ .076	$ .071	$ .084

* Whitfield. Iowa. 1958.

Kind of ration. The value of rations should be measured by net income and not by cost per ton of feed. High energy rations cost more per ton than the bulky, low energy rations, but do not require as many pounds to produce a pound of poultry meat or a dozen eggs (Table 8–12).

Commercial feed companies are seeking to provide more economical rations, because their feeds must produce results as good or better than their competitors.

Large poultry enterprises may save feed costs by varying the rations with the age, sex, and purpose for which fed. For example, as chickens grow older, their energy requirements increase. Expensive proteins and vitamins may be reduced and the less expensive energy grains increased in the rations (Table 12–4). Additional savings can be made by feeding a growing ration to broilers after six weeks until marketed, instead of continuing them on a starter ration. Restricted feeding of heavy breed layers or feeding heavy and light breeds a different type ration, is another example of how feed expenses may be reduced. Other possibilities are feeding different rations to males and females grown to broiler market age and feeding turkeys three rations—starter, grower, and finisher—instead of two rations as is frequently done.

Bulk delivery. The cost of bags and the labor of handling feed is averted through bulk delivery and storage (Fig. 6–4). The saving in feed cost generally amounts to about $3 00 per ton when purchased in four ton or larger amounts (Table 12–5). There is less wastage and drying out of feed in bulk delivery and storage. The storage bins do not take up valuable bird

Table 12–4

SEASONAL POULTRY FEED PRICES [1]

	Jan.	Apr.	July	Oct.
Starting and Growing Feeds				
Start and Grow Mash	$3.90	$4.07	$4.25	$4.03
Start and Grow Mash/Bifuran	4.02	4.19	4.37	4.15
Growing Mash	3.80	3.67	3.85	3.63
All-mash Developer	3.75	3.57	3.75	3.53
Laying and Breeding Feeds				
All-mash Layer Ration	3.62	3.52	3.77	3.57
Super Breeding Ration	3.95	4.24	4.40	4.14
Broiler Feeds				
Broiler Maker w/Nicarb./3-Nitro	4.11	4.20	4.42	4.22
Broiler Maker w/Nic./Nit./Antib.	4.35 [2]	4.60	4.61	4.39
Broiler Maker Finisher	3.85	3.91	4.18	3.98
Turkey Feeds				
Turkey Pre-Starter	5.15	5.34	5.53	5.28
Turkey Starting Mash 3N	4.43 [2]	4.64	4.82	4.56
Turkey Starting Mash/SQ3N	4.58 [3]	4.79	4.97	4.71
Turkey Developer 3N	3.92 [2]	4.07	4.29	3.98
Turkey Developer w/SQ3N	4.07 [3]	4.22	4.44	4.13
Turkey Finisher	3.76	3.78	4.06	3.85
Turkey Breeder all-mash	3.96 [2]	4.19	4.34	4.14
Turkey Breeder all-mash w/Histostat	4.08	4.31	4.46	4.26
Scratch Feeds				
Cracked Corn (coarse)	2.88	3.02	3.26	3.11
Feed Ingredients				
Soybean Oil Meal (44%)	3.00	3.66	4.09	3.70
Meat Scraps (50%)	3.93	5.00	6.08	5.30

[1] Farm Bureau Cooperative Association, Columbus, Ohio. *Prices/cwt. F.O.B., Springfield, Ohio, Mill, 1958.*
[2] Available only at Reading Plant.
[3] Does not contain 3-Nitro.

Table 12–5

INFLUENCE OF VOLUME AND BULK HANDLING ON FEED COST *

Observations	All-mash Rations		
	Chick Starter	Pullet Grower	Laying Mash
Price per 100 lb. bag	$4.30	$3 92	$3 87
Price per bag with return of bags (less 2%)	4 10	3 72	3 67
Bulk delivery (5 ton lots)	3 85	3 47	3 42
Bulk delivery (10 ton lots)	3.80	3.42	3 37

* Taylor, 1959.

housing space and the feed is protected from rats. Bulk delivery and storage eliminates the physical strain of handling sacks of feed.

Labor Saving Practices

The second largest cost factor in poultry production is for labor (Table 12–6). It may be reduced by the use of mechanical equipment (Table 12–7).

Automatic watering. Water should be piped to the poultry house, kept available at all times, with the amount regulated by drip or float valves (Fig. 6–3). The drinking vessels should be of such construction that they may be easily cleaned. Daily cleaning is advisable for some installations. A potable water supply for poultry is one of the best investments that can be made for the poultry enterprise.

Automatic feeding. The use of automatic feeders saves labor in feeding chickens and turkeys of all ages (Fig. 6–3). They are not economical for producers with less than about 1,000 layers. Feeding from a push-feed-cart or overhead conveyor saves labor and time, as does feeding from a bin rather than from sacks.

Table 12–6

EGG PRODUCTION COSTS AND INCOME ON A HYPOTHETICAL 5000 BIRD FARM PER YEAR *

Expenses			
Feed, 273 tons, @ $75 per ton			$22,000
Chicks, 4400 @ 36¢ per pullet chick			1,600
Labor 5000 hrs. @ $1.75 per hr.			8,000
4000 hr. family @ 1.75 per hr.			
1000 hr. hired @ 1.00 per hr. to clean and pack eggs.			
Miscellaneous—repairs, taxes, vaccines			1,200
Depreciation			1,100
Interest on investment @ 5%			850
Total expenses			$34,750
Income			
Culls, 4000 (80% cull rate) @ 50¢			$ 2,000
Manure			250
Changes in stock inventory			500
($11,500 at beginning of year and $12,000 at end)			
0–2 mo. of age	Value	$ .50	
2–4 mo. of age	Value	1.00	
4–5½ mo of age	Value	1.50	
5½ to 18 mo. of age	Value	2.00	
Over 18 mo. of age	Value	1.00	
Income other than for eggs			$ 2,750
Net cost			$32,000
Egg income 240 eggs (20 dozen) per bird × 5000 birds equals 100,000 dozen.			
Egg cost per dozen $32,000 ÷ 100,000 equals 32 cents per dozen.			

* Mercker 1959

Table 12–7

ESTIMATED LABOR COSTS PER 1000 LAYING HENS PER YEAR *

Work and Method	Flock Size		
	250	1,000	2,000
Feeding			
Automatic	$400.00	$160.00	$120.00
Manual	210.00	190.00	180.00
Watering			
Automatic	40.00	30.00	20.00
Manual	260.00	260.00	260.00
Egg gathering			
Manual	280.00	170.00	160.00
Egg cleaning and packing			
Mechanical	460.00	260.00	190.00
Manual	410.00	410.00	410.00
Litter handling			
Manual	30.00	25.00	24.00
Manure removal			
Mechanized	410.00	135.00	90.00
Manual	120.00	105.00	100.00

* Feathered Fax, November 25, 1958. Includes interest depreciation, repairs and 90¢/per hour for labor.

Litter use. Frequent change of litter is costly from the standpoint of labor and litter cost (Table 12–8). When starting a new brood of chicks, litter which has become caked, should be stirred and a small amount of clean litter added. A garden tractor may be used to loosen the litter. The deeper the litter, the greater its floor insulating value; and the more dry it is in winter, the less it will cake. Compost litter becomes pulverized in the same manner as sawdust or peat moss, which improves its value for absorption purposes. When the litter becomes too deep, part of it should be removed.

Litter and droppings removal and disposal. Droppings are the waste from about 50 per cent of the feed eaten. Frequent removal of droppings aids in keeping the house dry during winter. Use of dropping pits under the perches and placing feeders and waterers over them, helps to collect most of

Table 12–8

ECONOMY OF USING COMPOST LITTER *

Observations	New Litter		Compost Litter	
	Time	Cost	Time	Cost
Labor required per 1,000 broilers				
Cleaning	600 min.	$12.00	163 min.	$3.26
Adding fresh litter	50 min.	1.00	30 min.	.60
Stirring	67 min.	1.34	70 min.	1.40
Litter used per 1,000 broilers	1,400 lbs.	$10.50	525 lbs.	$3.94
Total		$24.84		$9.20

* Moore and Chamberlin.

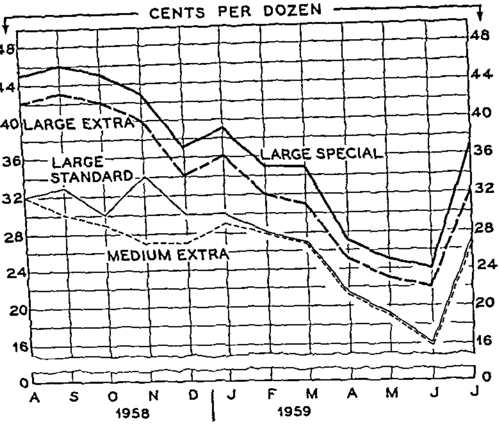


Fig. 12–4. Profits from eggs sold vary during year.

the droppings in one place. Pit cleaners, while costly to install, save labor and provide an efficient means for removal of droppings. Another satisfactory method is to provide house construction of such a nature that a tractor and manure spreader may be driven through the center of the house for ease of loading droppings and litter.

Litter and droppings have considerable fertilizer and mulching value for garden, nursery, crop, and pasture production. The composition of droppings will vary greatly with the moisture content (Table 12–9).

Litter and droppings may be spread on the ground in an open shed to a depth of a foot or more; stirred occasionally until dry enough (15 to 30 per cent moisture); ground and bagged; and sold in garden stores for $1.00 to $2.00 for a 50 to 75 pound bag

The fertilizer value of the manure produced by laying hens, broilers and turkeys has been calculated on Table 12–10. It amounts to 30–40 cents per year for a laying hen.

Egg Production

The stock, housing, feeding, disease control, egg handling, and method of marketing influences egg profits.

Selection of egg production stock. The goal today is to produce small

Table 12–9

ESTIMATED PLANT FOOD CONTENT PER TON OF POULTRY MANURE UNDER VARIOUS CONDITIONS *

Condition of manure	Nitrogen	Phosphorus	Potash
	Lbs.	Lbs.	Lbs.
Pure manure			
Dry	80	50	40
15–30% moisture (slightly dusty)	56	35	28
30–50% moisture (crumbly)	40	25	20
50–70% moisture (moist, sticky)	24	15	12
Manure and litter 50% moisture			
35% litter	28	17	14
50% litter	20	12.5	10
70% litter	12	7.5	6

* Missouri Agricultural Extension Service.

Table 12–10

AMOUNT & VALUE OF FERTILIZER CONSTITUENTS IN POULTRY MANURE WHEN PRODUCED UNDER AVERAGE CONDITIONS WITH NO PRESERVATIVES ADDED *

Number and Kind of Poultry	100 Hens			1000 Broilers	100 Turkeys
Kind of Manure	In pits, removed every 4 months	In Litter	Total	Built-up Litter	All Manure
Time Involved	1 Year	1 Year	1 Year	10 weeks	26 weeks
Nitrogen loss considered in calculations	50%	30%		30%	60%
Lbs. remaining present at end of period N	35	98	133	202	88
P_2O_5	54	109	163	165	93
K_2O	23	46	69	112	64
Commercial Fertilizer Equivalent	1,000 lbs. of 3.5–5–2	1,000 lbs. of 10–10–4	1,000 lbs. of 13–16–7	2,000 lbs. of 10–8–6	1,000 lbs. of 9–9–6
Total Value	$11.14	$26.29	$37 43	$49 85	$24 53
Value Per Head	.11	.26	.37	.05	.25

* Mo. Agr. Ext. Service.

birds which will lay large eggs, produce at a high rate, and continue production for a long time. It requires less feed to produce a dozen eggs when small birds are used because they require less feed for body maintenance (p. 277). Strain or other crosses of Leghorns (Chapter 5) are most popular for com-

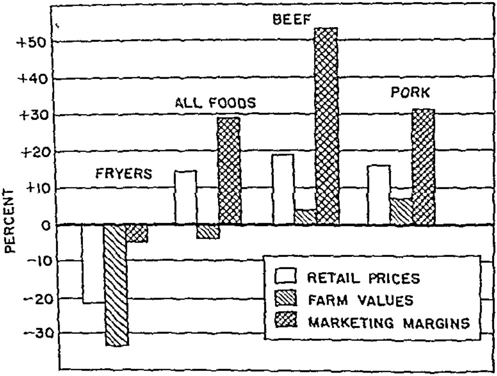


Fig. 12–5. Percentage changes in retail prices, farm values, and marketing margins on food products, 1949–1958.

mercial egg production. They are small birds and lay white eggs, which most markets prefer.

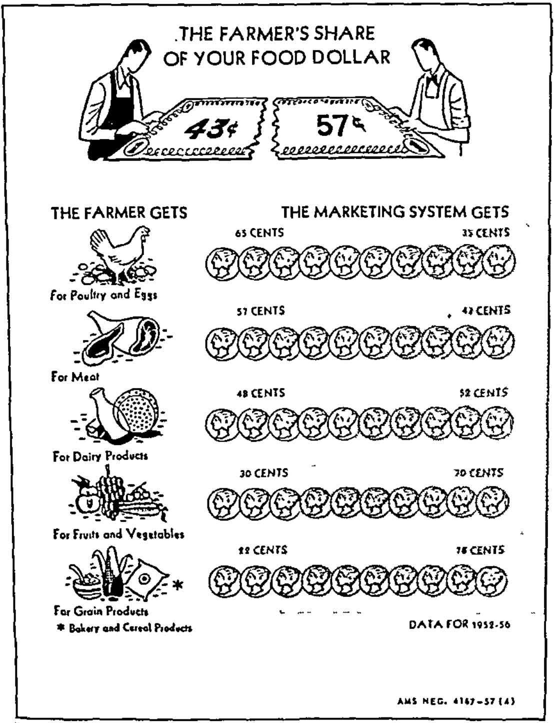
Performance of stock in random sample tests should be considered when buying pullets (Table 4–14 and p. 34).

Hatching date of stock influences later egg production and profits. Winter and early spring-hatched birds lay better (Table 12–11). The use of stimulighting and selection of breeding stock may reduce the seasonal factor in the future (p. 19).

Age of stock influences production. Most laying stock is profitable until about 20 months old.

Housing costs for egg production. Housing and equipment cost per layer varies from about \$2.00 to \$5.00 per bird, depending on the quality and amount of facilities provided (Table 7–9). The floor space requirements per layer have been reduced to about one square foot by fan ventilation, insulation, the use of pits, and multiple deck roosts (Fig. 7–1). Use of large pens which will accommodate several thousand birds eliminates the cost of partitions and saves labor in feeding, watering, and gathering of eggs.

Disease control. The presence of disease in a flock causes lowered egg production and higher mortality resulting in lower flock income (labor). New Hampshire farm production records indicate the following relationship between mortality and labor income:



U. S. D. A., A. M. S.

Fig. 12–6. The farmer's share of the food dollar.

Average annual mortality (per cent)	Labor income per hen
17.9	$0.78
12.8	1.42
8.8	1.59
3.3	1.74

Table 12–11

COST AND RETURNS ON LAYERS HATCHED DURING THREE SEASONS FOR THE PERIOD 24–76 WEEKS *

Observation	Date of Hatch		
	February	June	September
Production. Hen day basis			
Number	220	211	210
Per cent	60.3	57.6	57.3
Feed per hen started			
Per dozen eggs. Lbs.	5.1	4.9	5.1
Mortality. Per cent	8.8	11.1	7.5
Culled. Per cent	15.1	38.2	39.9
Average egg weight per doz. (oz.)	24.4	24.2	24.1
Costs per dozen (cents)			
Layer depreciation	.0832	.0900	.0923
Feed cost @ $0 035 per lb.	.1789	.1712	.1785
Marketing costs @ 2 cents doz.	.02	.02	.02
Depreciation on house and equipment	.0101	.0108	.0112
Misc.—water, litter, light	.0090	.0093	.0096
Interest on capital investment @ 5%	.0144	.0156	.0160
Total cost except labor	.3156	.3169	.3276
Returns—sale price	.3828	.3926	.3888
Labor income	.0672	.0757	.0612

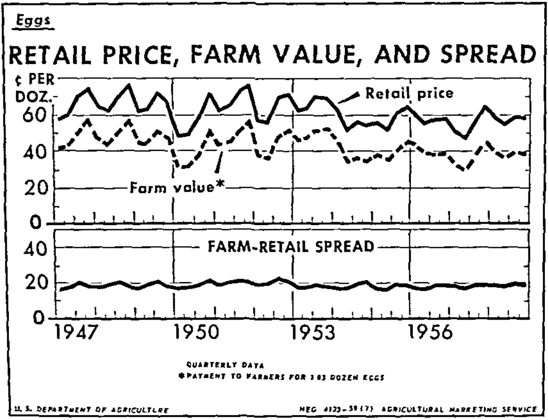
* Average results for three years 1955–57. Unpublished data. University of Missouri

Table 12–12

A STUDY OF LAYING FLOCK LABOR REQUIREMENTS ON CALIFORNIA POULTRY FARMS *

Observations	Types of Housing		
	Hen Cages	Floor Litter	Wire Floors
Number of farms	10	13	5
Flock size Ave.	3390	4220	4670
Max.	6140	7950	6790
Min.	1480	1150	1350
Egg production, percentage, Ave.	65.3	53.8	52.7
Max.	78.8	67.5	64.0
Min.	50 8	44 0	49.2
Total chore time, *man-minutes* Ave. bird-year	58.2	45.4	43.0
Min.	36.0	20.9	35.2
Total labor, *cases of eggs* Ave. man hour of labor	.68	.72	.74
Max.	1.05	1.39	1.00
Travel for feeding and gathering, feet per case Ave.	2300	1440	1180
Per Cent of total chores spent on feeding, gathering and cleaning eggs. Ave.	69.3	68.0	64.3

* Hart et al.



U. S. D. A., P. M. A.

Fig. 12–7. Farm to retail price spread for eggs.

Table 12–13

MORTALITY AND EGG PRODUCTION OF LAYERS ON THE FLOOR AND IN CAGES *

Observation	Floor		Cages	
	Ninth	Tenth	Ninth	Tenth
Mortality, 44–55 wks., per cent	1.5	1.2	1.4	1.0
" 19–55 wks., per cent	3.9	7.0	4.0	4.0
Eggs, 44–55 wks., hen/day basis	55	62	57	54
" 19–55 wks., " "	159	165	155	143
" " " ", per pullet housed	156	158	152	139
Extra large eggs, per cent	32.1	29.5	37.7	39.9
Large eggs, per cent	49.2	50.7	50.5	46.0
Medium eggs, per cent	18.1	19.0	11.4	13.6
Small eggs, per cent	.6	.7	.2	.5
Shell defects, per cent	.7	1.6	2.2	7.0
Blood spots, per cent	7.2	7.3	9.7	9.6
Meat spots, per cent	1.8	5.5	4.2	4.8
Shell thickness, mm.	.362	.378	.389	.394
Egg weight, ounces per dozen	24.8	25.2	25.4	25.8
Average Haugh Units	75	77	76	78

* California random sample tests, 1957–58.

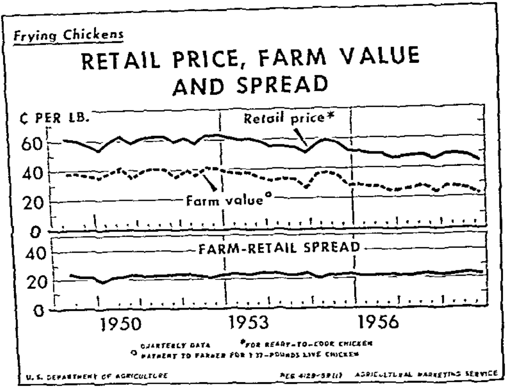


Fig. 12–8. Farm to retail price spread for frying chickens.

Floor space per layer influences production and profit (Fig. 7–3). As the floor space is reduced from three to one square foot per layer, production declines but net profit per layer increases.

Cage vs. floor pen egg production is an unsettled question from the standpoint of profit. Cage housing cost is low in warm climates (Fig. 7–28), but more expensive in colder climates. The housing space required per layer will vary with the arrangement of the cages (Fig. 7–29). The labor requirements per caged layer are higher than for floor pens (Table 12–12). Egg production and feed efficiency may be better for caged layers (Table 7–10). The quality of the eggs may also be slightly better (Table 12–13).

Feed cost for production. The feed required to produce a dozen eggs, varies from about 4.3 pounds for high-producing small hens on high energy rations (Table 7–10), to twice this amount for large broiler type breeding stock (Table 12–14). Assuming that 5 pounds of feed are required to produce a dozen eggs, a ration that costs $4.00 per hundred pounds will produce eggs for a feed cost of 5 cents per dozen less than for a ration costing $5.00 per hundred pounds. This sum alone may be more than the profit margin in producing eggs.

Egg handling. The largest item of labor in commercial egg production is the gathering, cleaning, and packing of eggs for market (Tables 12–12 and

Table 12–14

ARKANSAS POULTRY MEAT PRODUCTION TEST—1957–58. (15 ENTRIES)

Observation	Ave.	Range	
Egg phase *			
Production per hen housed. Per cent	49.4	41.7	65.7
Production per hen day. Per cent	51.8	42.7	70.6
Livability of layers. Per cent	91.0	87.0	95.0
Feed per doz. eggs produced. Lbs.	7.2	5.1	8.9
Age to sexual maturity (50 per cent production) days.	182	176	190
Av. body wt. at 5 mos. 3 wks. Lbs.	5.7	5.3	6.2
Av. body wt. at 14 mos. 3 wks. Lbs.	7.7	7.0	8.4
Fall egg size. Ounces per doz.	24.9	23.7	25.6
Spring egg size. Ounces per doz.	*27.4*	*26.4*	*28.4*
Hatchability and growth phase (Summer, 1958) **			
Fertility of eggs set. Per cent	76.1	61.3	83.7
Hatchability of eggs set. Per cent	57.0	39.9	63.7
Livability first 8 weeks. Per cent	97.7	89.6	99.6
Feed per pound of broiler. Lbs.	2.1	2.0	2.2
Males. Av. wt. at 8 wks. Lbs.	3.1	2.8	3.3
Females. Av. wt. at 8 wks. Lbs.	2.5	2.3	2.6

* Arkansas Poultry Improvement Ass'n. Report 81. 1958.
**Report 80. 1958.

Table 12–15

EGG CLEANING, SIZING AND CASING *

Work Done	Minutes Required per Case	
	Average	Range
Wash all eggs and case	9.9	
Wash all eggs, size and case	18.8	16.1–21.5
Wash dirty eggs only, size and case	22.2	17.0–32.0
Wash dirty eggs, candle, size and case	29.0	27.0–31.0
Wash all eggs, candle, size and case	27.1	21.0–35.0

* Ala.

15). The time involved is from 30 to 60 minutes per case depending on the labor saving facilities used.

The cost to produce and market a small egg as compared to a large egg is almost equivalent. Freshly laid eggs are nearly all of AA quality. The extra expense of labor and refrigeration in maintaining good egg quality on the farm amounts to 1¢–2¢ per dozen. The market price spread between large and medium and A and B eggs more than justifies the added expense of producing large grade A eggs (Fig. 12–4).

Estimation of cost of market egg production. The items to be considered are feed cost, flock depreciation, labor cost, and overhead. The latter

Table 12–16

RELATIVE COSTS OF PRODUCING MARKET AND HATCHING EGGS *

Observation	Market eggs		Hatching eggs		
	Light breeds Leghorn	Heavy breeds Production type	Light breeds Leghorn	Heavy breeds Meat type	Heavy breeds Production type
Number of flocks	23	28	20	19	14
Average number of layers	1,099	820	1,446	863	551
Egg production	203	192	174	167	190
Mortality. Per cent	19.3	17.9	14.1	15.8	20.5
Feed consumption. Lbs.					
Per bird	115	121.5	110.2	127.5	130
Per dozen eggs	6.8	7.6	8.0	10 0	8.9
Labor requirements					
Per bird. Hrs.	1.6	1.7	1.5	1.5	2.0
Per doz. eggs. Min.	5.9	6.6	6.5	7.1	8.4
Labor return per hr.	$1.45	$0.89	$1.32	$0.86	$0.90
Net cost per dozen eggs. Cents	$0.496	$0.514	$0.547	$0.743	$0.658

* Cornell Agricultural Experiment Station. Bul. 896.

includes heat, light, depreciation on buildings and equipment, and interest on investment. Overhead is usually figured at 12 to 15 per cent of the sum of the feed, flock depreciation, and labor costs.

Item of expense	Cost per dozen
Feed	
Lbs. per doz. x price per lb. =	______
Flock depreciation	
$\frac{\text{Value of pullet} - \text{salvage value}}{\text{Dozen eggs produced}} =$	______
Labor	
.11 x hourly rate	= ______
Total	______
Overhead	= ______
15% of above total =	______
Total cost egg production	______

Egg production income records. Several state agricultural colleges cooperate with farmers within their states in obtaining, analyzing, and publishing cost of production records. The University of Missouri was among the first group of colleges to compile such records (Table 12–17). In recent years, the income per layer, over feed cost, has been slightly less than $3.00.

Cornell University has made a study of the relations of labor income to size of egg production enterprise (Table 12–18). In 1957, the average labor income of ten farmers who owned more than 5,000 layers each, was $8,499.

The Iowa Agricultural Extension service reported an average labor income

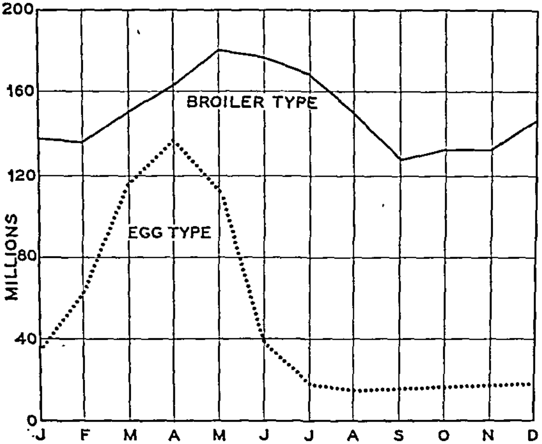


Fig. 12–9. Hatchery operation has become year-round business.

per hen at 70 cents during 1957–58 (Table 12–3), with the five highest flocks averaging \$1.45 and the five lowest a loss of \$0.24.

Market versus hatching egg production. More layers can be accommodated in a given floor space when producing market eggs than when producing hatching eggs for broiler production, because no males are kept and the laying hens are smaller (Table 12–2). The expense of blood testing is not incurred when producing market eggs. A New York study indicates

Table 12–17

A SUMMARY OF MISSOURI POULTRY FARM RECORDS

Year	Per Hen		
	Income	Feed Cost	Income over Feed Cost
1918	\$4.78	\$2.32	\$2.46
1928	4.61	2.38	2.23
1938	2.97	1.44	1.53
1948	8.95	6.13	2.82
1958	7.64	4.68	2.96

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	Light breeds Leghorn	Heavy breeds Production type	Light breeds Leghorn	Heavy breeds Meat type	Heavy breeds Production type
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Average number of layers	1,099	820	1,446	863	551
Egg production	203	192	174	167	190
Mortality. Per cent	19.3	17.9	14.1	15.8	20.5
Feed consumption. Lbs.					
Per bird	115	121.5	110.2	127.5	130
Per dozen eggs	6.8	7.6	8.0	10.0	8.9
Labor requirements					
Per bird. Hrs.	1.6	1.7	1.5	1.5	2.0
Per doz. eggs. Min.	5.9	6 6	6.5	7.1	8.4
Labor return per hr.	$1.45	$0.89	$1.32	$0.86	$0.90
Net cost per dozen eggs. Cents	$0 496	$0.514	$0.547	$0.743	$0 658

* Cornell Agricultural Experiment Station. Bul. 896.

includes heat, light, depreciation on buildings and equipment, and interest on investment. Overhead is usually figured at 12 to 15 per cent of the sum of the feed, flock depreciation, and labor costs.

Item of expense	Cost per dozen
Feed	
Lbs. per doz. x price per lb. =	______
Flock depreciation	
$\dfrac{\text{Value of pullet} - \text{salvage value}}{\text{Dozen eggs produced}} =$	______
Labor	
.11 x hourly rate	= ______
Total	= ______
Overhead	
15% of above total =	______
Total cost egg production	______

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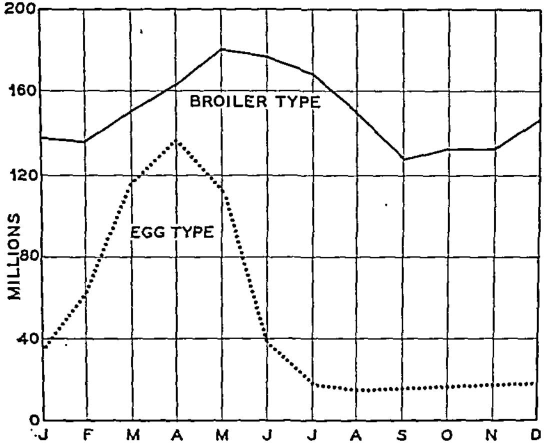

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Year	Per Hen		
	Income	Feed Cost	Income over Feed Cost
1918	\$4.78	\$2.32	\$2.46
1928	4.61	2.38	2.23
1938	2.97	1.44	1.53
1948	8.95	6.13	2.82
1958	7.64	4.68	2.96

Table 12–18

FARM BUSINESS SUMMARY OF 57 NEW YORK POULTRY FARMS IN 1957 *

Income and Production Factors	Size of Enterprise			
	Under 1,500	2,500 to 3,500	5,000 and up	All Flocks
Income factors				
No. of farms	10	14	10	57
Farm income	$2,806	$3,127	$12,432	$5,629
Labor income per farm	$1,503	$1,554	$8,499	$3,513
Production factors				
Ave. no. of layers	938	2,885	9,072	3,789
Eggs per layer	193	212	209	209
Layer mortality, per cent	.15	.14	.22	.16
Chick and pullet mortality, per cent	.05	.14	.08	.08
Doz. eggs sold per man	10,866	32,928	54,820	33,295
Price received per dozen	.45¢	.43¢	.41¢	.42¢
Feed per doz. eggs. Lbs.	8.3	5.9	6.2	6.2

* Jasper and Earle. N. Y. 1958.

that eggs hatched for broiler production cost about 25 cents more per dozen to produce than market eggs (Table 12–16).

Marketing Eggs

The cost to market eggs is less than for most farm products (Fig. 12–5 and 6).

The spread between farm sale price and consumer purchase price is about 20 cents per dozen (Fig. 12–6). In the midwest, the principal marketing costs per dozen eggs in 1956 were: retailer, 10 cents; city distributor (wholesaler), 3.3 cents; and the country assembly plant, 8.2 cents. The city distributor or wholesaler is now being eliminated. More direct marketing by some producers lessens the spread between the farm sale and consumer purchase price for eggs.

Table 12–19

EGG ASSEMBLY PLANT COSTS *

Charge	Cost per dozen
Freight to eastern markets	$0.027
Labor	.007
Cases, fillers, and other supplies	.02
Payments to buyers and independent dealers	.024
Trucking from buying stations	.006
Overhead, miscellaneous costs and profits	.011
Total	$0.095

* U. S. D. A. Misc. Publ. 741 1957.

Egg assembly plant costs in the midwestern states in 1956 have been summarized in Table 12–19. The costs amounted to nearly 10¢ per dozen. Most of the payments to buyers and independent dealers have now been eliminated. Trucking costs are less than perishable freight car rates. Labor saving equipment in handling, sizing, inspecting, and cartoning eggs has aided in preventing much of a rise in egg assembly plant costs (Chapter 10).

Wholesaler costs of grading, cartoning, and handling eggs in 1956 amounted to nearly 7¢ per dozen (Table 12–20). Most of the wholesaler's work is now done at the egg assembly plant with the elimination of part of the labor costs and miscellaneous and overhead costs.

Table 12–20

WHOLESALER COSTS OF GRADING AND CARTONING EGGS *

Charge	Cost per dozen
Labor	$0.025
Cartons	.022
Inspection	.002
Miscellaneous costs	.006
Overhead and profit	.013
Total	$0.068

* U. S. D. A. Misc. Pub. 741. 1957.

Ohio egg co-operative charges in 1958 for supplying cases, picking up eggs, sizing, candling, cartoning, selling, and delivery of eggs to retailers amounted to about 7¢ per dozen (Table 12–21).

Table 12–21

DISTRIBUTION OF COSTS OF A CENTRAL OHIO CO-OPERATIVE EGG ASSEMBLY PLANT DURING THE 1958–59 FISCAL YEAR

Operating cost	*Cost per dozen*
Plant operating cost	$0.028
Cases	.014
Delivery to retailers	.006
Farm pick-up	.008
Administration and promotion	.007
General	.003
Total	$0.066

Rearing Replacement Pullets

Rearing replacement pullets for commercial egg producers is one of the newest developments in the highly specialized poultry business. The first

move in this direction took place when egg farmers began to buy sexed pullets. They can now buy pullets that have been vaccinated and are ready to lay. The egg farmer need not tie-up part of his facilities for rearing pullets only part of the year. He may purchase any number of pullets and have them delivered at any time of the year. This is especially helpful to the cage operator who must cull heavily and at the same time keep his cages filled in order to make a profit.

Production costs, excepting labor, for rearing replacement pullets to various ages have been estimated by the Beacon Milling Company (Table 12–22). The principal items of cost are feed, chicks, and labor. A 16-week old pullet is at a profitable age for selling. Excepting labor, it costs from \$1.10–\$1.20 to raise a pullet to this age.

Iowa farm record data for 1957–58 indicate the total cost of producing a 20-week old pullet to be about \$1.80 (Table 12–23).

Table 12–24 illustrates a method to figure the total cost of raising replacement pullets to 20 weeks of age.

Broiler Production

Broiler production has become second in importance among the specialized poultry production enterprises (Fig. 1–7). In spite of the rising cost

Table 12–22

CUMULATIVE COST BY WEEKS FOR GROWING SMALL-TYPE LEGHORN REPLACEMENT PULLETS *

Week	Chick Cents	Litter Cents	Fuel Cents	Misc.** Cents	Feed Cents	Total Dollars
1	40	60	1.00	1.0	1.05	\$0.44
2	40.2	.60	1.51	2 0	2.63	.47
3	40.4	.61	2.01	2.0	4.73	.50
4	40.6	61	2.51	2.5	7.35	.54
5	40 8	.61	3.01	2 5	10.50	.57
6	41.0	.62	3 03	2.5	14.44	.62
7	41 2	.62	3.04	3.5	18 44	.67
8	41.4	62	3.06	3.5	22.92	.71
9	41.6	62	3.07	3.5	27.63	.76
10	41.8	1.23	3.09	5.5	32.57	.84
11	42 0	1.23	3.10	5.5	37.75	.90
12	42 2	1 24	3.12	5.5	42.93	.95
13	42 4	1.25	3.13	5.5	48.35	1.01
14	42 6	1.25	3.15	5.5	53.77	1.06
15	42 8	1.26	3.16	5.5	59.42	1.12
16	43.0	1 26	3.18	6.0	64 96	1.18
17	43.2	1 27	3.19	6.0	70.74	1.24
18	43.4	1 28	3.21	6.0	76.51	1.30
19	43 6	1.28	3.22	6 0	82.29	1.36
20	43.8	1.29	3 24	6 0	88.06	1.42

* Beacon Milling Co. 1959 Cayuga, N Y
** Includes vaccination, medication and insurance.

Table 12–23

IOWA FARM EGG PRODUCTION RECORD SUMMARIES *

Financial statement for young stock project	Average of 18 flocks—chicks	5 high-cost pullets	5 low-cost pullets
1. Number of chicks started	604	644	641
2. Per cent mortality at 5 months	11.7	18.5	6.0
3. a. Chick cost (Raised)	$ 0.47	$ 0.54	$ 0.42
b. Fuel cost (Raised)	$ 0.04	$ 0.04	$ 0.03
c. Feed cost (Raised)	$ 0.77	$ 0.97	$ 0.62
d. House and equip. cost (Raised)	$ 0.08	$ 0.10	$ 0.08
e. Miscellaneous costs (Raised)	$ 0.02	$ 0.02	$ 0.02
f. Total cost per bird raised	$ 1.38	$ 1.67	$ 1.17
4. Total expense per lb. poultry raised	$ 0.36	$ 0.40	$ 0.31
5. Pounds poultry raised	2,047	2,189	2,265
6. Pounds feed used	11,967	12,299	12,242
7. Pounds of feed per pound raised	5.8	5.6	5.4
8. Net cost of pullet except labor	$ 1.41	$ 1.74	$ 1.18
9. Net income except labor	$208.92	$113.76	$312.21
10. Hours labor per 100 birds	21.0	22.3	17.5
11. Income per hour	$ 1.80	$ 0.97	$ 3.12
12. Value put on each pullet kept	$ 1.83	$ 1.98	$ 1.87
13. Cost per lb. or ration fed	$ 0.034	$ 0.04	$ 0.031
14. Pounds of feed per pullet (5 months)	22.4	23.4	20.3

* Whitfield.

Table 12–24

FORMULA FOR ESTIMATING COST OF RAISING LEGHORN PULLETS TO 20 WEEKS *

Item	Calculation		Cost
Feed	22 lbs. x price per lb.	equals	...
Labor	11 min. x value per minute	equals	...
Chicks	1.1 x price per chick	equals	...
Other items	Add 12% of total cost of feed, labor, and chicks	equals	...
Total	Cost per pullet	equals	..

* Taylor.

of most commodities, the price of broilers has declined in recent years. Better feed conversion (Table 12–25) and the use of labor saving methods (Table 12–26) are cited as the cause. With the use of automatic feeders, waterers, and other labor saving devices, 1,000 broilers can be raised to market age with 40 to 60 hours of labor.

Production costs for broilers are mainly for feed, chicks, and labor. A 1958 Maryland broiler production report showed the feed cost to be 62 per cent, the chick cost 21 per cent, and the labor cost 10 per cent of the total (Table 12–28).

Feed efficiency is generally referred to as the number of pounds of feed required to produce a pound of poultry meat. The smaller the number, the

Table 12–25

CHANGES IN MAINE BROILER PRODUCTION *

Observation	1950	1957
Average size of flock	7,524	11,564
Lots sold per year	2.5	4
Mortality, Per cent	6.0	3.2
Age at sale. Weeks	13.5	10.5
Ave. weight when sold. Lbs.	3.9	3.6
Feed conversion (lbs. of feed per lb. of gain)	4.2	2.8
Production costs. Cents/lb	26.0	20.4

* Saunders.

Table 12–26

LABOR REQUIREMENTS PER 1000 BROILERS SOLD *

No of Birds per Brood	Hours of Labor per 1000 Broilers					
	No. of Producers	Preparing House	1–2 weeks	3–6 weeks	7 and up weeks	Total
1,000–1,999	9	19	34	72	75	200
2,000–2,999	28	17	20	43	51	131
3,000–3,999	18	12	14	23	25	74
4,000–4,999	20	11	12	22	23	68
5,000–5,999	10	12	10	18	15	55
6,000–6,999	2	6	5	14	17	42
7,000–7,999	6	9	10	20	18	57
8,000–8,999	3	10	9	19	25	63
9,000–9,999	2	9	10	17	15	51
Ave. all producers	.	12	14	26	28	80

* Whit and Windham.

better the conversion. As birds become larger and older, the feed efficiency ratio increases (Table 8–9). The influence of feed conversion and price on the cost of producing poultry meat is shown in Table 12–27.

Farm to retail price spread. The difference between farm and retail price range, although fluctuating temporarily, has remained fairly constant in recent years (Fig. 12–7). Conloque (1957) reported a spread of 15¢–22¢ per pound from live bird to ready-for-the-oven ice packed poultry and 27¢–36¢ for frozen poultry. Processing plant costs amounted to about 7¢ per pound (Table 12–29), transportation 0.5¢, wholesaler 2.5¢, and chain store retailer 8.5¢–11¢. Recently, retailers have been operating on more narrow profit margins, because of the increased volume of business. Wholesaler margins have also been largely eliminated.

Broiler processing costs are about 5¢ per pound in small plants and 3¢ per pound in large operations (Table 12–30). Added to this sum, is the transportation cost which amounts to 0.5¢–1¢ per pound depending on distance to market.

Table 12–27

COST TO PRODUCE 1,000 POUNDS LIVE POULTRY AT VARIOUS FEED PRICES AND CONVERSION RATIOS.*

Conversion Ratio	Per Ton	115.00	110.00	105.00	100.00	95.00	90.00	85.00	80.00	75.00	70.00	65.00
Feed to Meat	Per 100 Lbs.	5.75	5.50	5.25	5.00	4.75	4.50	4 25	4.00	3.75	3.50	3.25
3.50 to 1	....	201.25	192.50	183.75	175.00	166.25	157.50	148.75	140.00	131.25	122.50	113.75
3.40 to 1	....	195.50	187.00	178.50	170.00	161.50	153.00	144.50	136.00	127.50	119.00	110.50
3.30 to 1	....	189.75	181.50	173.25	165.00	156.75	148.50	140.25	132.00	123.75	115.50	107.25
3.20 to 1	....	184 00	176.00	168.00	160.00	152.00	144.00	136.00	128.00	120.00	112.00	104.00
3.10 to 1	....	178.25	170.50	162.75	155.00	147.25	139.50	131.75	124.00	116.25	108.50	100.75
3.00 to 1	...	172.50	165.00	157.50	150.00	142.50	135.00	127.50	120.00	112.50	105.00	97.50
2.90 to 1	....	166.75	159.50	152.25	145.00	137.75	130.50	123.25	116.00	108.75	101.50	94.25
2.80 to 1	....	161.00	154.00	147.00	140.00	133.00	126.00	119.00	112.00	105.00	98.00	91.00
2.70 to 1	....	155.25	148.50	141.75	135.00	128.25	121.50	114.75	108.00	101.25	94.50	87.75
2.60 to 1	...	149.50	143 00	136.50	130.00	123.50	117.00	110.50	104.00	97.50	91.00	84.50
2.50 to 1	...	143 75	137.50	131.25	125.00	118.75	112.50	106.25	100.00	93.75	87.50	81.25
2.40 to 1	...	138 00	132.00	126.00	120.00	114.00	108.00	102.00	96.00	90.00	84.00	78.00
2.30 to 1	..	132 25	126.50	120.75	115.00	109.25	103.50	97.75	92.00	86.25	80.50	74.75
2.20 to 1	...	126 50	121.00	115.50	110.00	104.50	99.00	93.50	88.00	82.50	77.00	71.50
2.10 to 1		120.75	115.50	110.25	105.00	99.75	94.50	89.25	84.00	78.75	73.50	68.25
2.00 to 1		115 00	110 00	105.00	100.00	95.00	90.00	85.00	80.00	75.00	70.00	65.00
1.90 to 1	..	109 25	104.50	99.75	95 00	90.25	85.50	80.75	76.00	71.25	66.50	61.75
1.80 to 1		103.50	99 00	94.50	90.00	85.50	81.00	76.50	72.00	67.50	63.00	58.50
1.70 to 1		97.75	93.50	89.25	85.00	80.75	76.50	72.25	68.00	63.75	59.50	55.25
1.60 to 1	...	92.00	88.00	84.00	80.00	76.00	72.00	68.00	64.00	60.00	56.00	52.00
1.50 to 1		86.25	82 50	78.75	75.00	71.25	67.50	63.75	60.00	56.25	52.50	48.75

* Broiler Industry, November, 1958.

Table 12–28

BROILER PRODUCTION COSTS

Charge	Amount Cost per pound	Per cent of total
Feed	$0.11	62
Chicks	.04	21
Vaccine	.0025	
Fuel	.0050	
Litter	.0025	
Producer	.0175	10
Total	$0.1775	

Table 12–29

BROILER PROCESSOR CHARGES *

Charge	Cents per pound
Assembly of chickens from farm	0.75
Feeding birds at plant	.25
Processing and packaging labor	3.00
Boxes and other packaging material	1.00
Freight to market	1.25
Overhead, miscellaneous cost and profit	1.25
Total	7.50

* U. S. D. A. Misc. Pub. 741, 1957.

Hatchery Chick Production

Hatchery operation has become a year-round business for most operators because of the broiler and started pullet business (Fig. 12–8). Since most hatcheries operate all year, the volume of chicks per egg capacity is increased and the cost of production per chick reduced.

Chick costs. Hatching eggs account for more than 60 per cent of the chick production cost (Table 12–31). Commercial, unsexed chick costs range from about 9¢–14¢ depending on egg costs, the size of the hatchery, efficiency of operation, and advertising. Pullet chicks generally cost about twice as much as unsexed (straight-run) chicks plus 1¢ per chick for sexing. Chicks with special breeding cost more.

Turkey Meat Production

Turkey meat production is a highly specialized branch of the poultry industry. It involves the production of large turkeys for the hotel and restaurant trade, and small turkeys, including turkey fryers, for family consumption.

Costs of turkey meat production are 20¢–25¢ per pound (Table 12–32).

Table 12–30

COSTS * OF PROCESSING BROILERS IN FOUR RANGES OF PLANT SIZE IN NORTH CAROLINA **

Item	Costs in Dollars per 100 Pounds			
	Birds Processed per Hour			
	150–599	600–1,199	1,200–2,399	2,400–3,999
Labor (1)	2.35	1.60	1.42	1.41
Water, Power, Light, & Ice	.25	.21	.23	.25
Heat & Fuel	.08	.06	.06	.04
Packaging Material (2)	1.00	1.00	1.00	1.00
Uniforms (3)	.03	.03	.03	.03
Misc.	.03	.04	.03	.04
Total variable costs	3.74	2.94	2.77	2.77
Interest Costs (4)	.11	.07	.07	.06
Depreciation (5)	.20	.14	.14	.14
Maintenance	.04	.05	.08	.10
Admin. Costs	.76	.48	.36	.27
Total fixed costs (6)	1.11	.74	.65	.57
Average total cost	4.85	3.68	3.42	3.34

* Management was adjusted for output and all plants were standardized for a 40 hour week.
(1) Labor @ $1.00 per hour.
(2) Packaging material @ $1.00 per 100 lbs.
(3) Uniforms charged @ 3¢ per 100 lbs.
(4) Interest on value of building and equipment @ 6%.
(5) Depreciation basis—20 years for buildings, 5 years for equipment.
(6) Cost of land, insurance and taxes not included.
** Donald and Libeau.

Poult costs are high, about 40¢–80¢ each, because of the cost in keeping turkey breeders, seasonal production, and hatching.

Turkey processing costs include about one-fourth to one-half hour labor and 25¢–50¢ for packaging per bird (Table 12–33).

Contract Poultry Farming

As poultry production has changed from general farm, small-scale operations to large-scale broiler and egg enterprises, contract farming has come into the picture to provide more capital, divide the risks, and obtain better markets. The contract may be a flat-fee, an incentive bonus coupled with the flat-fee, or a partnership arrangement. Whatever the plan, the terms of the agreement should be in writing with all parties receiving a notarized copy.

Integration. To integrate means to make whole or complete by adding or bringing together parts. *Vertical integration* refers to the grouping of different but related industries which are necessary in the production of poultry such as hatcheries, feed manufacturers, broiler producers, and processing plants.

Horizontal integration occurs when a chain or group of grocery stores, hatcheries, or feed mills, are brought under one ownership or management.

Table 12–31

COST OF SALEABLE CHICKS (RANGE FOR 6 HATCHERIES) *

Observation	Range	
Annual production of saleable chicks	635,000	7,130,000
Cost of hatching eggs	7.9¢	9.2¢
Incubating and hatching costs	0.9	3.5
Labor	0.51	1.4
Power, fuel and water	0.07	0.24
Chick boxes, pads, etc.	0.11	0.54
Supplies and fumigants	0 01	.16
Insurance	.01	.23
Repairs	.00	.38
Taxes, local and payroll	.02	.16
Depreciation	.17	.43
Selling and delivery	.05	1.37
Delivery expense	.03	.17
Travel and entertainment	.00	.12
Advertising and promotion	.01	.15
Commission and salaries	.00	.94
General and administrative	.03	2.16
Salaries, communications, office supplies, legal, bad debts, interest, adjustments, etc.		
Total cost per chick	9.69	14.06

* Taggart.

Table 12–32

TURKEY PRODUCTION COSTS *

Observation	Mature weight	Fryer weight
Average weight (lbs.)	20	7–8
Weight of hens (lbs.)	14	
Weight of toms (lbs.)	25	
Age when sold. Hens (wks.)	21–24	13 to 17
Toms (wks.)	25 to 29	13 to 17
Feed cost per lb. (cents)	14.5 to 16	13 to 15
Poult cost per lb. (cents)	3 to 3.5	4.5 to 8
Misc. cost per lb (cents)	1.6	2.0
Labor cost per lb. (cents)	1.5	2.0
Total cash costs per lb. (cents)	21.3	24 to 25
Interest on investment per lb. (cents)	0.6	.3 to .4
Depreciation per lb. (cents)	0.9	.5 to .6
Total cost per lb. (cents)	22.8	25

* Peterson.

The form of integration developing in agriculture and especially in the poultry business is primarily vertical integration.

The development of integrated poultry operations is causing a decrease of middlemen in the channels of trade, such as the country store, local buyer,

Table 12–33

A SURVEY OF LABOR REQUIREMENTS IN SIX TEXAS TURKEY PROCESSING PLANTS *

Observation		Labor Requirements per 100 Turkeys. (Hours)		
		Ave.	High	Low
Hens				
Dressing		8.7	20.0	3.1
Evisceration		12.0	20.0	7.1
Packaging		3.5	4.7	1.9
Packing		2.3	2.8	1.8
	Total	26.5	47.5	13.9
Toms				
Dressing		10.6	25.0	4.7
Evisceration		16.8	33.3	10.1
Packaging		3.3	4.7	2.3
Packing		3.1	3.4	2.7
	Total	33.8	66.4	19.8

* Texas Agr. Exp. Sta. Misc Pub. 133.

central buying station or processor, the wholesale receiver, the broker, the jobber, and the retailer. In more complete integration, the production operations (chicks, feed, etc.) and marketing are performed by one management or firm.

The advantages of integration are greater than the disadvantages. Integrated units can produce a large amount of uniform products, such as broilers or eggs. The quality is also more uniform because usually a single strain of stock and feed and less numerous but larger flocks are involved. Larger quantities also lead to cheaper prices for chicks and feed. The processor can pay more for large quantities of uniform supplies. Large distributors, such as the food chains, can depend on a steady supply of broilers and eggs. The producer is assured of a market.

About the only disadvantage with integrated units, is that the producer has to give up some of his independence. Some of the management decisions are made by the integrator (manager of the integrated enterprise).

Broiler production contracts. Broiler production has become largely an integrated business. The parties financially interested, in addition to the grower, are usually one or more of the following: feed dealer, hatcheryman, processor, and food chain store system.

There are several types of contracts in which the grower may participate. The most successful is an incentive type contract in which the grower is paid a certain amount, usually one-half cent per bird per week, plus a bonus for improved growth rate, reduced mortality, and improved feed conversion. In such a plan the grower generally supplies the housing equipment and labor. The integrater supplies the chicks, feed, and medicine and picks up the birds for marketing.

Broiler growers prefer an integrated contract to operating independently

although they may not need credit, because it divides the risk and insures a market.

Egg production contracts. Egg contracting is more recent than broiler contracting. Producers, egg assembly plants, and feed companies are generally involved. The arrangement assures the producer of a market and financial assistance for production; the egg marketing or assembly plant has a steady supply of high quality eggs; and the feed manufacturer, an outlet for his feed.

The egg franchise contract involves the producer, processor, and feed man. The feed company helps the processor and producer find a market for a uniform, large volume of high quality eggs. The net return to the producer may be 2¢ or more per dozen above what he would obtain if the eggs were sold locally. The producer uses a specified strain of poultry and feeds a designated brand of feed. These requirements help to produce more uniform market eggs.

The egg production incentive contract (Table 12–34) pays a base price of

Table 12–34

AN INCENTIVE EGG PRODUCTION CONTRACT *

Observation	Payment to producer per dozen
Base payment for	
Clean eggs	6 cents
Soiled eggs	3 cents
Mortality. Receives per dozen for each 5% below 30%	0.5
Production. Receives per dozen for each 10 eggs above 220	0.5
Feed consumption. Receives per dozen for each 5 lbs. below 130	0.5

* Driggers. Producer supplies all labor housing and equipment. Contractor supplies the chicks, feed, egg cases and picks up the eggs.

6¢ per dozen for clean eggs, plus a bonus for egg production above 220 eggs per year, mortality below 30 per cent, and feed consumption below 130 pounds. The producer supplies the labor, housing, and equipment. The contractor supplies the chicks, feed, egg cases, and picks up the eggs for the market.

The co-operative egg contract is between the egg assembly plant and the producer. The latter agrees to gather the eggs three times daily, clean the soiled eggs according to approved methods, pack and store them in a controlled room or egg cooler with a temperature of 60–65° F. and a relative humidity of 70 to 80 per cent, and dispose of birds that have been in production 15 months. The egg assembly plant supplies the cases, picks up the eggs twice per week, candles and sizes them, and pays the producer the Urner-Barry quotation for nearby extra fancy heavy weights.

Share contract farming. This system of farming is one in which the landlord supplies most of the capital and the grower supplies the labor. The North Carolina Agricultural Extension Service (Extension Service Folder 102) has suggested the following contracts:

50–50 arrangement for egg production in which the landlord supplies all capital (land, housing, equipment, stock, and feed) and the tenant provides all labor. They divide income evenly from eggs, culls, and old hens.

⅓–⅔ arrangement for turkey production where the landlord supplies the land, buildings, equipment, and ⅓ of the poult, feed, medicine, fuel, and marketing costs, and the tenant provides the labor and ⅔ of the poult, feed, medicine, fuel, and marketing costs. The income from sale of turkeys is divided ⅓ to the landlord and ⅔ to the tenant.

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Chapter 13

Turkey Production

TURKEYS ARE NATIVE to America (Fig. 13–1). Before 1492 they were unknown to European or Asiatic civilizations. The Aztec Indians of Mexico had domesticated the wild turkey, and as early as 1498 the Spanish imported turkeys to Spain. The birds proved very popular and apparently readily adjusted themselves to their new environment. As early as 1573 it is reported that they were plentiful in England. Domesticated turkeys were brought to New England by the early colonists from Europe and served as a nucleus from which the turkey industry of the United States developed.

Varieties

The Standard varieties, Bronze, White, Holland, Bourbon Red, Narragansett, Black, Slate and Beltsville Small White were developed from the wild stock or from varieties descended from the wild stock. The weights of these varieties as given in the American Standard of Perfection are as follows:

Variety	Adult Tom	Yearling Tom	Young Tom	Adult Hen	Yearling Hen	Young Hen
Bronze	36	33	25	20	18	16
White Holland ..	33	30	25	18	17	14
Narragansett, Bourbon Red, Black, and Slate	33	30	23	18	16	14
Beltsville Small White	23	22	19	13	12	11

Popularity of the respective varieties. The most popular variety of turkeys in the United States continues to be the Bronze. However, the Large Whites (including White Hollands) are more popular in the North Atlantic and East North Central States. For the year 1957–8 the breeding flocks reported for the National Improvement Plan were distributed by regions as shown in Table 13–1.

Bronze. The Bronze turkey has color markings similar to the wild turkey native to the Mississippi Valley and the eastern part of the United States (Fig. 13–2). The white markings in the tail, however, probably trace their

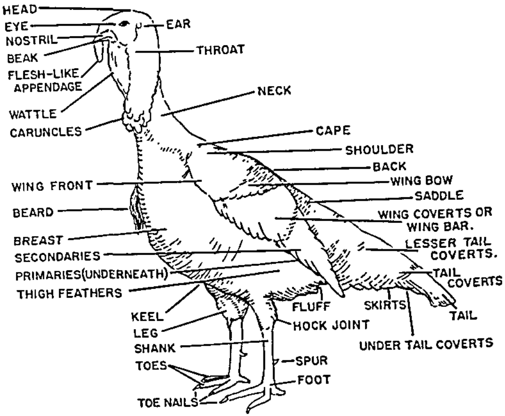

Fig. 13–1. Nomenclature of the turkey.

origin to the Mexican wild stock. The New England wild turkey has brown instead of white in the color pattern of the tail. During the nineteenth century the domesticated Bronze turkey was crossed with the wild New England stock.

The popularity of Bronze turkeys can be partly attributed to their resemblance to the beautiful wild stock, their vitality, their size, and the fact that they have been in the hands of progressive breeders. It is necessary to see these birds in their fully mature plumage to appreciate their beauty. The development of this color pattern may have been at the neglect of vitality and market qualities in some cases, but this variety has remained a popular turkey with the growers.

White Holland. The White Holland turkey takes its name from its solid white color and the fact that it was supposedly brought to America by the early Dutch colonists from Holland. A white variety originated in Europe probably as a "sport" from the Mexican stock imported by the Spaniards. However, the White Hollands which were developed in America very likely came from white "sports" from the Bronze variety.

Bourbon Red. This variety was developed by Mr. J. F. Barbee of Bourbon County, Kentucky, from crosses made about 1890. Mr. Barbee crossed Bronze,

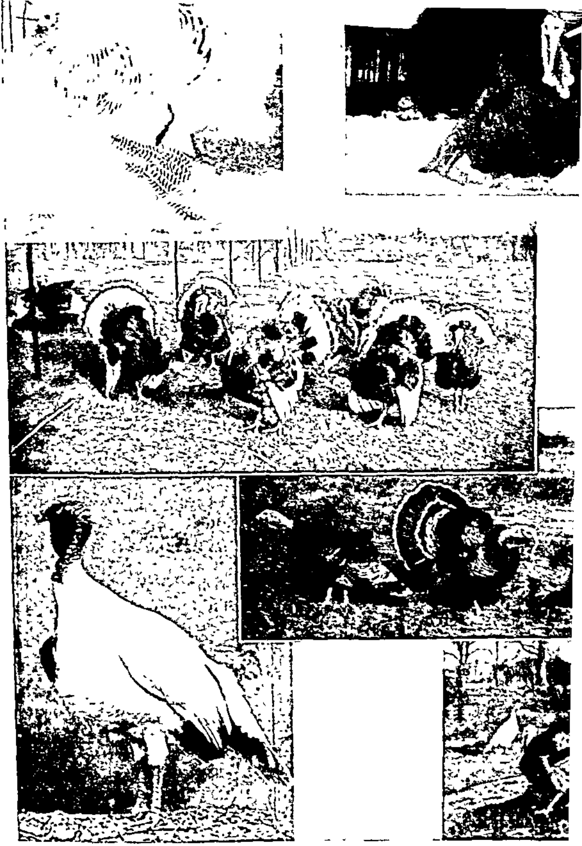

Fig. 13-2. Breeds of turkeys. Top left, Narragansett. (Courtesy Hawkeye Turkey Farm and "Turkey World.") Top right, Black. (Courtesy "Turkey World.") Center left, Bourbon Red. (Courtesy Pleasant Valley Turkey Farm.) Center right, Bronze. (Courtesy Wallace Neel.) Bottom left, White Holland. (Courtesy U. S. D. A.) Bottom right, Slate. (Courtesy Wingert Turkey Farm.)

Table 13–1

DISTRIBUTION OF TURKEY VARIETIES.

	Broad Breasted Bronze	Standard Bronze	Large White	Beltsville Small White	Others
North Atlantic	33	1	62	2	1
East North Central ..	46	2	51	1	...
West North Central.	65	Less than 0.5	21	7	7
South Atlantic	52	Less than 0.5	7	40	Less than 0.5
South Central	68	...	22	11	Less than 0.5
Western	95	Less than 0.5	2	3	Less than 0.5
U. S................	72	Less than 0.5	17	9	2

White Holland, and Buff varieties and selected from these crosses the birds which were red with white primaries, secondaries, and main tail feathers. This is a beautiful variety with good market qualities. The modern type and color pattern are illustrated in Figure 13–2.

Narragansett. This variety takes its name from Narragansett Bay, the region in which it originated. It probably arose as the result of crossing the Norfolk Black, which the English colonists brought with them, with the New England wild stock and by later introducing some Mexican wild stock. This variety is somewhat similar in appearance to the Bronze. However, the birds are lighter in color and lack the copperish bronze markings which characterize the Bronze turkey.

Black. The Blacks probably originated as "sports" from the turkeys introduced into Europe by the Spaniards. They were called the Black Norfolks and were later brought to America by the colonists. Black turkeys sometimes occur in flocks of Bronze turkeys. The importance of this variety in the past appears to have been its value as one of the parents for developing new varieties. Its relatively smaller size and its well-developed breast may make this variety more popular as a market turkey. A very good Black specimen is shown in Figure 13–2.

Slate. This variety is supposed to have originated in America from the crossing of Black Norfolks and White Hollands. The birds have slate or ash-blue plumage. Slate turkeys have never been popular in the United States and at present relatively few birds of this variety are raised in this country. They have the same standard weight as the Black variety.

Beltsville Small White. This small variety of turkeys was developed by research workers at the U. S. D. A., Beltsville Research Center. They have proved especially popular for the production of turkey broilers or small roasting turkeys.

Nonstandard varieties. Several large-type, white turkeys are gaining in popularity. They are the Broad Whites, Empire Whites, Lancaster Whites, and others are likely to appear soon.

The future of the turkey industry depends quite largely on the success which may be achieved in breeding for market qualities and for birds which are efficient producers of human food.

Breeding Objectives

Color patterns. Turkey breeders should select for the color pattern desired in their respective varieties. Most of these color patterns are very well fixed, so that little attention need be paid to such characters. To neglect important market qualities and focus attention on fine distinctions in color designs is a mistake. The most successful breeders in the future will emphasize market qualities but retain also the color pattern of their varieties.

Market qualities. Since the turkey is a meat animal, it should be bred for the most desirable market type and size. Already some breeders have made considerable progress in this direction. As in other animals, size and type are heritable characters which may be influenced by selection. Birds with compact bodies are being used quite extensively in turkey matings and attention is being centered on market quality. No doubt there are many market qualities other than size and shape which should be emphasized. Early maturity is receiving attention and it should be emphasized because the efficiency of the turkey as a producer of human food is dependent somewhat upon early maturity. The ability of the bird to grow mature plumage at an early age, fattening or finishing while yet young and probably immature, the texture of meat, and the distribution of fat are all market qualities which should receive the attention of the breeder.

Size of turkey to raise. The producer should strive to satisfy the demands of the markets for turkeys as long as it is profitable to do so. Those who are emphasizing small size in turkeys should bear in mind that the overhead cost per pound for small turkeys is greater than for large turkeys. It is also true that the hotels and restaurants prefer the larger birds because they can get more servings per pound of large turkey. Hen turkeys, because of their smaller size and excellent quality, are in demand for family use. Table 13–2 shows the results obtained from a rather extensive survey made by the National Association of Food Chains for the purpose of determining from their customers the demand for turkeys of different sizes. It will be observed that 50 per cent of the consumers patronizing the chain food stores preferred turkeys under twelve pounds. The Delaware station gathered some data (Table 13–3) on this problem in the city of Wilmington which showed that restaurants and wealthy customers have a very definite preference for turkeys weighing over thirteen pounds. It is evident that various sizes are in demand.

Egg production. Economical poult production requires high egg production in the breeding stock. Egg production in turkeys as in chickens can

Table 13–2

CONSUMER DEMAND FOR TURKEYS BY SIZE OF BIRD

Size of Turkey	Proportion of Total Demand *
Group 1 (8 and 9 pounds)........	25%
Group 2 (10 and 11 pounds)........	25%
Group 3 (12 and 13 pounds)........	23%
Group 4 (14 and 15 pounds)........	14%
Group 5 (16 and 17 pounds)........	8%
Group 6 (18 pounds and over)......	5%

* Represents weighted average of all returns to make allowances for the varying sizes of reporting companies.

Table 13–3

NUMBER OF CONSUMERS AND RESTAURANTS PREFERRING VARIOUS SIZES OF TURKEYS *

Sizes of Turkeys	All Consumers		Wealthy Consumers		Restaurants	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
6 pounds..............	1	.5	...	...	...	...
8 pounds	5	.5	...	.	...	...
9 to 10 pounds.........	49	27.1	4	21.0	...	...
11 to 12 pounds	50	27.6	4	21.0	1	4.8
13 to 15 pounds..	42	23.2	5	26.3	8	38.1
Over 15 pounds........	38	21.0	6	31.7	12	57.1

* Del. Sta. Bul. 21B

be increased by proper breeding. The basis of selection must be trap-nest records and progeny test records.

Unless the consumption of turkeys becomes less seasonal so that there is a greater demand for turkeys throughout the year, poult production will remain highly seasonal and there will be little demand for turkey eggs out of the regular hatching season. Under the present conditions early egg production and intensive production are most desirable. As in chickens, early sexual maturity and intensity of production are inherited characters which can be modified by breeding as well as by feeding and management.

Factors related to annual egg production in turkeys have been investigated by Asmundson at the California Agricultural Experiment Station, Davis, California. He found that annual production was influenced most by (1) date of last egg, or the bird's persistency; (2) length of pause, or time out of production; (3) date of first egg, or starting early in the season; and (4) net spring rate of production. From these results it would appear that to increase annual egg production in turkeys, they must be bred for persistency and intensity of production without rest periods, and they must be bred and so managed that they start laying early in the season.

Young hens lay more eggs than do older birds. Records of egg production kept at the California station showed the following production per hen: first

year, 77 eggs; second year, 50 eggs; third year, 44 eggs; fourth year, 45 eggs; and fifth year, 28 eggs. Egg production is reduced when turkey hens are permitted to remain broody and hatch their eggs. Date of hatching is also a factor influencing time of egg production. Early-hatched birds often lay during the winter months while late-hatched birds may not lay until late spring.

The elimination of inherited defects. The California station has shown that pendulous crops in turkeys are inherited. In matings which they made the percentage of offspring developing pendulous crops varied from none to 100 per cent. They were also able to show that the occurrence of pendulous crops was greatly increased when turkeys were raised where the temperature was high, the humidity low, and where there was much sunshine. They concluded that the tendency for turkeys to develop pendulous crops was determined by one pair of recessive autosomal genes. If pendulous crops are inherited in the manner these investigators believe them to be, the breeder could eliminate this defect only by progeny testing his birds, and discarding any which produced offspring developing this condition. This condition cannot be eliminated by merely culling turkeys that develop pendulous crops (Fig. 9-30).

The Kansas Agricultural Experiment Station has shown that in chickens the tendency to develop crooked breastbones is inherited. It appears logical to assume that in turkeys crooked breastbones also may be inherited. Birds showing evidence of crooked breastbones should be marketed and thereby kept out of the breeding pens.

The progressive turkey breeder will not only select breeding stock free from market defects but he will study the inheritance of these defects and by scientific breeding eliminate them from his strain of turkeys.

Selection of Breeding Stock

The success of any breeding program depends upon the stock used in the breeding pens. Young birds which are intended for breeding purposes should be selected in the fall before any birds are marketed. Otherwise, some of the best birds may be sold and therefore lost for breeding.

The basis of selection should be, of course, those qualities which the breeder hopes to establish in his strain of birds. Since turkeys are produced primarily for meat, selection for desirable market characteristics should be considered fundamental in any turkey-breeding program. The market prefers a turkey which has a long, wide, and deep breast, and a compact body which is well-fleshed and covered with fat. The market also prefers turkeys which have well-matured plumage and few pinfeathers when dressed.

The Oklahoma Agricultural Experiment Station has reported results which show that such measurements as keel length, body depth in front, and shank length may be used as a basis for selecting turkeys at market age. Advancement can be made along these lines by breeding.

The specialty breeder who uses trap nests will make selection also on the basis of pedigrees and progeny records.

S. J. Marsden, Poultry Husbandman in charge of turkey investigations for the United States Department of Agriculture, has prepared the following outline for selecting turkey breeders:

I. Head
  A. Bright, round, outstanding eyes of proper variety color. Reject if off-colored, elongated, dull, sunken, injured, blind, or missing.
  B. Short, curved beak. Reject for ostrich beak, cross beak, and elongated beak but not for proper debeaking.
  C. Rugged but refined appearance, free from excess flesh. Reject for coarseness or weak appearance.
  D. Good depth and breadth, not elongated. Reject for crowhead.

II. Back.
  A. Wide and flat including part over ribs (heart girth). Reject for reach (arched) back, crooked back, narrow heart girth, or torn skin.

III. Breast
  A. Wide but not excessively so. Reject if too narrow or too wide and flat (Fig. 13–3).
  B. Parallel to back. Reject if rear end of keel appears pushed in or dropped down away from the parallel position.
  C. Smooth-fleshed, width carried well back to rear of keel but not so much as to interfere with locomotion. Reject for heart-shaped breast (very wide in front and very narrow at rear).
  D. Breastbone (keel); straight, moderately long, free from knobbiness. Remove birds with crooked keels, noticeably curved, too short, decidedly rocker-shaped, decidedly dented, or possessing a knob which is the result of failure of flesh to cover the front point of the keel. Breastbone should be about the same length as the shank.
  E. Check crop region and reject for signs of pendulous crop.

IV. Legs and feet
  A. Drumsticks: plump, well-meated, and of a size sufficient to balance the rest of the body. *Reject if undersized or straight-sided.*
  B. Shanks of moderate length, strong, sturdy, not too short or too long, not coarse. Reject for legginess or abnormally short shanks.
  C. Reject for off-color, crooked toes, twisted shank, or any tendency toward bowlegs, knock-knees, slipped tendons, swollen hocks, or malformed hocks. One or two slightly crooked toes permitted in females but not in males.

V. Wings and tail
  A Reject for split wing, slipped wing, twisted or off-colored wing and tail feathers. Clipped wing(s) permitted on females but not on males.

VI. Balance
  Depends primarily upon leg placement; birds poorly balanced have legs placed too far back. Balance is indicated by:

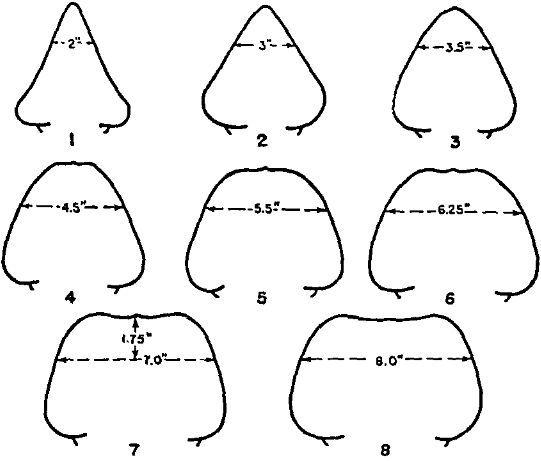

Fig. 13–3. Cross sections of turkeys' bodies at the widest point of the breast slightly to rear of front tip of keel bone.

A. Keel-leg relationship when bird is suspended by the legs, the body vertical and relaxed. Well-balanced birds show no decided gap between drumsticks and rear end of keel, the profile appearing smooth. Reject poorly balanced birds with a conspicuous gap showing a broken or notched profile. Keel should extend well back between the legs.

VII. Skeletal proportions

A. Moderate depth; keel nearly equal in length to the shank in market-age birds; slightly longer than shank in birds 32 weeks and older. Body depth should be about one-fifth greater than length of the keel in all except Beltsville Small Whites in which it should be about one-fourth greater. Measure by calipers or by spread of hand. Reject for shallow body or short keel.

VIII. Color

A. Conforming reasonably well to standard requirements. Reject for all standard disqualifications relating to color of plumage, legs, and feet and also for solidly "off-colored" beak or eyes. Reject males of Bronze, Bourbon Red, Narragansett, and other parti-colored varieties that do not have male-colored plumage and females that do

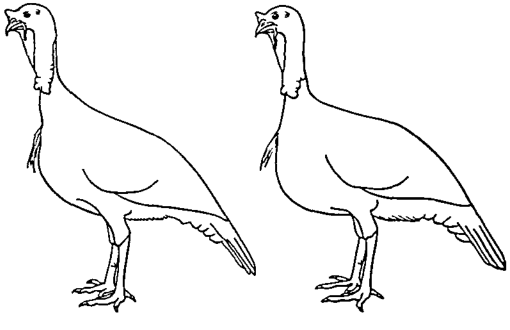

Fig. 13–4. Drawings representing turkeys with good and poor balance.

not have female-colored plumage such as those lacking the normal white edgings on breast and body feathers. Reject Bronze turkeys for completely black backs and complete or almost complete lack of body bronzing and tail penciling.

IX. Size

A. Check for weight according to variety and age (Table 13–4). Weigh representative specimens. Reject for decided underweight or overweight.

X. Quick market maturity (Quick maturing turkeys are more efficient in the use of feed.)

The state of maturity can be checked accurately and effectively only where age is known and then only at 22 to 26 weeks for small-type and 24 to 30 for medium- and large-type turkeys. Quick maturing specimens will have the most market finish at the ages indicated.

A. Good market finish is indicated by:

1. Fat in skin. Have an assistant hold the bird so that breast skin is relaxed, then pluck a few feathers from the sparsely feathered area between the two feather tracts of the breast at a point just to rear of a line drawn from shoulder to front point of keel. Take a fold of skin between thumbs and forefingers of both hands. Grade A turkeys will have a creamy skin, a fold of which (containing a double thickness of skin) is about .07 to .14 inch thick; U. S. Grade B, .04 inch; and U. S. Grade C, .03

Table 13–4

SUGGESTED MINIMUM BODY WEIGHTS FOR STANDARD AND BELTSVILLE SMALL WHITE VARIETIES AND SUGGESTED MAXIMUM BODY WEIGHTS FOR SMALL VARIETIES OF TURKEYS *

Sex and Age	Minimum Body Weight				Maximum Body Weight	
	Broad-Breasted Bronze	Standard varieties other than Bronze	Standard Bronze	Beltsville Small White	Beltsville Small White	Other small varieties
Toms:	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
24 weeks........	18	14	15	12	16	17.5
26 weeks........	20	15.5	16.5	13.5	18	19.5
28 weeks........	22	17	18	15	20	21.5
30 weeks.......	23	18	19	16	22	23.5
32 weeks........	24	19	20	17	23	24.5
Hens:						
24 weeks........	12	8.5	9.5	7	10	11
26 weeks........	12.5	9	10	7.5	10.5	11.5
28 weeks.......	13	9.5	10.5	8	11	12
30 weeks........	13.5	10	11	8.5	12	13
32 weeks........	14	10.5	11.5	9	12.5	13.5

* U.S.D.A., A.H.D. 113.

inch or less. This test is effective only at the point described. Ignore fat in skin at other places on the body.

2. *Pinfeathers long enough to be plucked cleanly.* U. S. Grade A dressed turkeys are permitted to have a few short pinfeathers, but only a very small number on the breast. In the live bird, check for pinfeathers too short to be picked on drumsticks, shoulders, and one of the two narrow feather tracts that run parallel to the keel and just above it on either side.

Reject birds not showing proper degree of maturity (U. S. Grade A finish for small-type at 24–26 weeks, or large- and medium-type at 28–30 weeks). In the absence of a thorough check as above eliminate all obviously late-maturing specimens.

XI. Carriage and action (especially important in the selection of males).

A. Carriage (the bird standing or walking but not strutting): Birds with good balance stand high at the shoulders, the back sloping from front to rear at a 35–40° angle. Reject for front-heaviness (Fig. 13–4).

B. Action: Gait free, active, and easy. Reject for waddling, limping, paddling (swinging feet outwards), or crippled condition.

Matings

Age of breeding stock. Young hens and toms that are well matured are usually more satisfactory for breeding purposes. For the production of market turkeys this appears to be the most practical method to follow because the

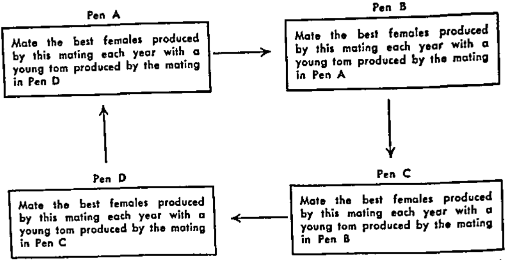

Fig. 13–5. A systematic breeding plan for the breeder who desires to produce his own breeding stock and avoid close inbreeding.

females produce more eggs during their first laying season, fertility and hatchability are generally higher when young stock is mated, and the cost of keeping breeding stock from one season to another is eliminated. The progressive breeder who pedigrees his stock and uses progeny records must keep breeding stock for several seasons. From the data given in Table 13–5 it is

Table 13–5

EFFECT OF AGE OF TURKEY BREEDING STOCK ON EGG PRODUCTION *

Age of Stock (Years)	Average Egg Production	First Egg After January 1 (Days)
1	76.6	67.3
2	49.5	78.8
3	44.2	80.3
4	44.6	87.6
5	27.6	96.2

* Asmundson and Lloyd, University of California.

evident that young turkey breeding females will produce more eggs during the breeding season and these eggs will be produced earlier in the season than if older birds are used.

Single male matings. Single male matings are necessary where pedigreed breeding methods are being followed, so that ancestry may be traced and progeny tests made. Where males are placed in adjoining breeding pens it is advisable to place some material such as burlap on the fence so that the males cannot see each other. Otherwise they exhaust their energy by parading before each other, "gobbling," and attempting to fight.

Flock matings. Large-scale turkey production has resulted in mass or flock matings where several males are used. In flock matings one tom is used

for each fifteen to twenty females. A very simple method for preventing the males from fighting and the fertility from thereby being reduced is to confine the males in individual pens with openings only large enough for the females to pass through. These pens should be so arranged that the hens have to pass through to get feed or water.

Artificial Insemination. The use of artificial insemination has become a common practice among commercial breeders in order to insure higher fertility of large-sized, broad breasted varieties. This practice though economically sound is not recommended for replacement stock as there is danger of developing strains that are unable to produce naturally. Artificial insemination provides a means of increasing the fertility from valuable toms, old or crippled, which cannot mate naturally.

Pedigree breeding of turkeys. The realization that the market qualities of turkeys are inherited has led to the pedigree breeding of turkeys. The trap nest (Fig. 13–6) has been found to be a practical device for determining the egg production of individual turkey hens and also for identifying the eggs laid by different birds. A record of all matings should be kept which shows the male and females used in each pen. An incubator record should also be kept which shows for each hen the number of eggs set, the number of infertile eggs, the number of dead embryos, and the poults hatched. Each poult should be wing-banded and suitable records kept so that the pedigree of any pedigreed bird can be determined at any time.

By keeping progeny records, valuable male and female breeding stock can be identified and better families can be kept and the inferior ones discarded. It is only by such methods that the breeder can hope to make much progress in breeding turkeys.

Breeding systems. Three systems of breeding are used in breeding turkeys: inbreeding, outbreeding, and crossbreeding. Close inbreeding (brother and sister, etc.) results in low hatchability, low fertility, high mortality, slow growth, and late maturity. There is considerable variation in reproductive performance and body conformation between strains of turkeys. The crossing of pure strains that combine well takes advantage of hybrid vigor or heterosis in producing progeny superior to either parent strain. Studies at Ohio, Utah and Minnesota Agriculture Experiment Stations have consistently shown improvement in reproductive traits with strain crossing. Mating distantly related birds is a desirable method for the breeder who is doing pedigreed breeding to use in establishing desirable characters in his strain of turkeys.

Most turkey growers who are not interested in doing pedigree breeding find that outbreeding is the best system for them to follow. They can purchase breeding males from some breeder who is breeding the type they want. These males are mated with females selected from their own flock. They can purchase stock from the same breeder year after year with little danger of ill effects from inbreeding. Those who wish to do so may produce their own toms, if they have several individual mating pens, by following the plan shown in Figure 13–5. With four pens (A, B, C, D) the best male produced each year from the mating in pen A would be placed in B the following year;

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Fig. 13–6. Turkey hen entering trap nest. Note the doors on top for removing the birds from the nests and the hen's number painted on the saddle for identification.

but the best females raised from the A mating would remain in pen A for the following breeding season, to be mated with the best male produced by the mating in pen D. The management of the other pens would be similar in that males produced in B would go to C and those produced in C to D.

Crossbreeding is sometimes used, but the crossing of the different varieties of turkeys has not, as yet, proved enough superior to outcrossing to justify its use. Turkey breeders and growers prefer to raise purebred stock.

Management of Breeding Stock

The failure of a turkey-breeding program can be traced frequently to the mismanagement of the breeding stock. While turkeys given their freedom on the farm may produce more fertile eggs than when kept under artificial conditions, they do respond to good management and produce maximum results when they have proper care and management.

Range or yards. During recent years there has been a change from range to yards for turkey-breeding stock. In those regions where blackhead is a serious turkey disease this change has been necessary in order to prevent all range from becoming contaminated with the organisms which cause this disease. The most practical yarding system is one where green feed can be grown in the yards. Wire fences from 3 to 6 feet high will confine turkeys if the yards are level and they cannot perch or roost on the fence. For single male matings yards 40′ x 120′ provide sufficient green feed. Gravel, crushed stone, or cinders placed around the house or roosting quarters help to maintain more sanitary conditions in the yards. Very small yards about 15 or 20

feet square covered by about 3 or 4 inches of gravel, crushed stone, or cinders, may be used for single male matings. Results reported by the Pennsylvania Agricultural Experiment Station showed that breeding stock could be closely confined in such pens without interfering with breeding results. When confined in yards where there is no growing green feed, both cod liver oil and a high-grade alfalfa meal should be fed. The use of some fresh green feed was reported by the Pennsylvania station to increase hatching results even though 5 per cent of alfalfa meal was used in the mash.

Turkey breeders confined in buildings should be provided with 12 to 15 square feet of floor space per bird. The use of artificial light is usually necessary to prevent a delay in egg production. The toms should be lighted two to three weeks earlier than the hens when artificial lights are used. Floors should be covered with litter. The difficulty of obtaining satisfactory results with complete confinement has limited the widespread use of this practice to northern areas where weather conditions are unfavorable early in the breeding season.

Housing. The need for protection of turkeys against cold and rainy weather depends upon the climatic conditions which prevail where they are kept. They are generally considered to be less susceptible to the effects of weather than are chickens, and therefore require less protection. In most sections of the United States all that is required is roosting quarters protected by a roof and three walls. Adult turkeys may be confined in houses with satisfactory results, but the most economical provision for the southern part of the United States appears to be outside roosts only. For the northern part of the United States and Canada roosting sheds should be protected on the north, east, and west sides against winds, rain, and snow. The Kansas and Purdue Agriculture Experiment Stations have reported that housing was not necessary for turkey breeding stock in their respective states. Portable range shelters, partially enclosed, are often utilized for shelter in the breeding pens.

Roosts (2″ x 4″) laid flat or four-inch poles provide satisfactory roosts for turkeys. Each bird should have about eighteen inches of space on the roosts. Open top boxes 2′ x 2′ and 10 to 12 inches deep supplied with some nesting material such as straw, excelsior, or cane pulp make very satisfactory nests. They may be located in the house or in some secluded spot in the yard. Where special breeding work is done, trap nests protected from rain and snow are used (Fig. 13–6). The house should provide about 8 to 10 square feet of floor space per bird so that plenty of room for feeders, waterers, and the birds will be available.

Artificial lighting. That turkeys may be brought into production as much as two months before they would otherwise lay, by using artificial lights, has been demonstrated by several investigators. The use of lights will usually bring mature turkeys into production within thirty days after the lights are started. The lights may be turned on early in the morning or all-night lights may be used. Figure 13–7 shows the results obtained at the Missouri Agricultural Experiment Station when all-night lights were used on Bronze turkey hens during their first laying season.

The Pennsylvania Station has reported that it is necessary to expose toms to lights at least one week or longer before the hens are placed under lights to insure satisfactory early fertility. Work at the Oklahoma Station indicates that for Oklahoma conditions both toms and hens respond to lights within the same length of time. These differences between the Pennsylvania and Oklahoma results are likely due to climate.

Turkeys are seasonal breeders; however, it is possible to obtain economical production of hatching eggs during the summer and fall months by the use of controlled artificial lighting. This is accomplished through the use of restricted day-length to stimulate and maintain egg production. The restriction of day-length to nine hours during the conditioning period followed by 15 hours of artificial light has proved to maintain satisfactory egg production.

Feeding. *Suitable rations are necessary for high egg production and good* hatchability. These rations may be similar to those used for feeding chicken *breeding stock.* Farmers who raise chickens and turkeys may use the same mash for both kinds of breeding stock, if extra vitamins A, D, and riboflavin are added to the turkey ration (Table 13–6). Breeding turkey toms will con-

Table 13–6

SUGGESTED NUTRIENT LEVELS IN TURKEY RATIONS. *

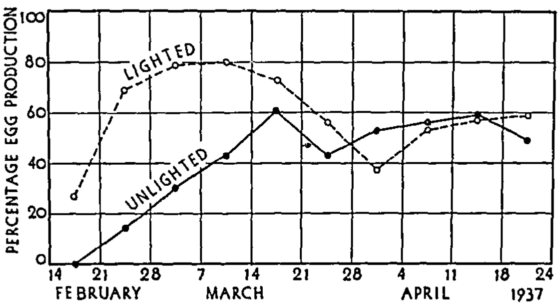
Nutrient	0–6 wks.	6–12 wks.	12–18 wks.	18–24 wks.	Breeders
Productive energy, cal./lb.	850–950	850–950	850–950	850–950	850–950
Crude protein, %	28–31	22–24	17–19	14–16	15–17.5
Calorie/protein ratios [1]	30	40	50	60–65	55
Calcium, %	1.75–2.00	1.75–2.00	1.60–2.00	1.60–2.00	2.25
Phosphorus, total, %	0.9–1.0	0.9–1.0	0.9–1.0	0.9–1.0	0.75–0.80
available, %	0.5–0.6	0.5–0.6	0.5–0.6	0.5–0.6	0.5
Manganese, mgs./lb.	25–30	25–30	25–30	25–30	25–30
Salt, iodized %	0.4–0.5	0.4–0.5	0.4–0.5	0.4–0.5	0.25–0.5
Vitamin A, IU/lb	4000–5000	4000–5000	4000–5000	4000–5000	4500–5000
Vitamin D_3, ICU/lb	600	600	600	600	600
Riboflavin, mg /lb.	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0
Niacin, mg /lb	28–35	24–30	24–30	24–30	15
Pantothenic acid, mg /lb	6.0–8.0	5.0–7.0	5.0–7.0	5.0–7.0	8.0–9.0
Choline, mg /lb.	800–900	800–900	800–900	800–900	450
Vitamin B_{12}, mcg./lb.	4.0–5.0	3.0–4.0	3.0–4.0	3.0–4.0	3.0
Folic acid, mg /lb	0.5	0.4–0.5	0.4–0.5	0.4–0.5	0.32
Vitamin E, mg./lb. added	2.5–5.0	2.5–5.0	2.5–5.0	2.5–5.0	2.5–5.0
Vitamin K, mg /lb [2]	0.8	0.8	0.8	0.8	0.8
Antibiotics [3]	+	+	+	+	+
Antioxidants [3]	+	+	+	+	+
Unidentified factors [3]	+ +	+	+	+	+ +

[1] In growing turkeys, widening the calorie-protein ratio will produce better *carcass finish In the 21–24 weeks* period widening the calorie-protein ratio to 65 is desirable and may be accomplished by feeding extra corn.
[2] Added as menadione If the poults have access to green pasture, this may be omitted from the diet.
[3] See text concerning addition of these factors
* Md. Ext. Service Fact Sheet 139 1958.

sume about six pounds of feed per week and for the same period the females will consume about three pounds of feed. The cost of feed is the principal item of expense in keeping breeding stock.

Rations for turkey breeding stock. Rations which are *satisfactory* for feeding chicken-breeding stock can be used for feeding turkey-breeding stock, if properly fortified by minerals and vitamins (Table 13–7).

Protection of females against injury in mating. Turkey hens are frequently injured seriously by large toms tearing their backs while mating.



COURTESY MISSOURI AGRICULTURAL EXPERIMENT STATION

Fig. 13–7. Effect of all-night lights on egg production in turkeys.

To prevent these injuries the sharp toenails and spurs of the toms may be clipped, or "saddles" may be placed on the females. Many producers are protecting the females by placing canvas "saddles" on them (Figure 13–6). This should be done before the breeding season begins.

Cost of keeping breeding stock. The breeder who is following a scientific breeding program must keep breeding stock throughout the year. The cost of keeping this stock is a considerable item and includes labor, returns on investment in stock, equipment, and land, losses from mortality, depreciation, and feed costs (Table 8–8).

Hatchery supply flocks. The development of specialized poult production by hatcheries has created a demand for turkey-hatching eggs. Many turkey eggs are shipped to hatcheries in the North Central states from California, Texas, and other southern states. However, the advent of pole-type shelters and the application of artificial light to obtain early hatching eggs in the northern states has eliminated the need of purchasing turkey eggs from producers located in more favorable climates.

THE NATIONAL TURKEY IMPROVEMENT PLAN

The primary objectives of this plan are to improve the production and market quality of turkeys and to reduce losses from hatchery disseminated diseases. The Plan provides for four breeding stages and two pullorum-typhoid classes. Some provisions of the Plan are:

Definitions

Official State Agency—The state authority recognized by the United States Department of Agriculture to cooperate in the administration of the Plan.

Affiliated Flock Owner—A flock owner who is participating in the Plan through an agreement with a participating hatchery.

Table 13-7

TURKEY RATIONS (1)
1958 REVISION

Mash Ingredients		All-Mash Starter	All-Mash Grower	Grower *	All-Mash Breeder
Ground yellow corn		800	950	795	1,195
Standard wheat middlings		100	200	200	200
Fish meal (60%)		200	50	50	100
Meat and bone scrap (50%)		100	...	50	50
Soybean oil meal (44%)		650	580	680	250
Alfalfa meal (17%) (100,000 A/lb)		60	60	60	60
Dried corn distillers solubles or equiv.		50	50	60	50
Dicalcium phosphate or equiv.		15	55	40	32
Ground limestone (feeding grade)		30	50	55	55
Iodized salt		5	10	10	10
Manganese sulfate or equiv.		0.25	0.25	0.25	0.25
Antibiotic supplement		...	...	...	...
Vitamin Supplements:					
Vitamin A	(IU)	4,086,000	4,086,000	4,086,000	4,086,000
Vitamin D	(ICU)	1,021,500	1,021,500	1,021,500	1,021,500
Vitamin E	(IU)	10,000	10,000	10,000	30,000
Vitamin B_{12}	(mg)	6	6	12	12
Choline chloride	(mg)	415,150	80,500	134,550	415,150
Riboflavin	(mg)	4,190	4,190	5,255	5,000
Calcium Pantothenate	(mg)	3,706	3,706	4,578	10,900
Niacin	(mg)	45,600	45,600	46,000	50,000
Totals		2,010.25	2,005.25	2,000.25	2,002.25

CALCULATED ANALYSIS OF TURKEY RATIONS

		Starter	Grower	Grower	Breeder
Productive energy	Cal/lb	890	870	851	926
Protein	%	28 8	21.5	24.6	17.8
Fat	%	3.4	2.9	2.9	3.7
Fiber	%	3 9	4.1	4.2	3.5
Calcium	%	2.0	2.0	2.18	2.12
Total phosphorus	%	1.07	1.0	1.01	0.93
Readily available phosphorus	%	0.82	0.72	0.73	0.69
Manganese	mg/lb.	26.1	27.2	28.2	26 0
Vitamin A	IU/lb.	5,932	6,127	5,966	6,414
Vitamin D	ICU/lb.	510	510	510	510
Riboflavin	mg/lb.	3.7	3.4	4.1	3.8
Pantothenic acid	mg/lb.	6.1	6.1	6.7	8.7
Choline	mg/lb.	952	665	774	685
Niacin	mg/lb.	39.5	37.1	39.6	40.6

(1) 1959 recommendations of the New England College Conference Board.
* To be fed with grain after twelve weeks.

Flock—As applied to breeding, all turkeys of one kind of mating (variety or combination of stocks) and of one classification on the farm.

Baby Poults—Poults that have not been fed or watered.

Strain—Turkey breeding stock bearing a given name produced by a breeder through at least five generations of closed flock breeding.

Broad-breasted—A term used to describe a type of turkey which at the time of selection, and no later than 30 weeks of age, has a breast width at a point 1¾ inches above the keel of at least 3½ inches, for both toms and hens.

Participation

(a) Any person producing or dealing in poultry products may participate in the Plan when he has (1) demonstrated, to the satisfaction of the Official State Agency, that his facilities, personnel, and practices are adequate for carrying out the applicable provisions of the Plan; and (2) signed an agreement with the Official State Agency to comply with the general and the applicable specific provisions of the Plan and any regulations of the Official State Agency.

(b) Each participant shall comply with the Plan throughout the operating year of the Official State Agency, or until released by such Agency.

(c) A participant in any State shall participate with all of his turkey hatching egg supply flocks and hatchery operations within such states.

Specific Provisions for Participating Flocks

(a) Poultry houses and the land in the immediate vicinity thereof shall be kept in sanitary condition acceptable to the Official State Agency.

(b) All flocks shall consist of birds that have been selected for health, vigor and freedom from physical deformities of economic importance by an Authorized Agent or State Inspector.

(c) A flock shall be deemed to be a participating flock at any time only if it has been officially blood tested within the past 12 months with no pullorum or typhoid reactors on the last test.

(d) Each bird shall be identified with a sealed and numbered band obtained through or approved by the Official State Agency.

Specific Provisions for Participating Hatcheries

(a) Hatcheries, including brooder rooms, shall be kept in sanitary condition, acceptable to the Official State Agency. The minimum requirements with respect to sanitation shall include the following:

(1) Incubator walls, floors and trays shall be kept free from broken eggs and egg shells.

(2) Tops of incubators and hatchers shall be kept clean (not used for storage).

(3) Entire hatchery, including sales room, shall be kept in a neat, orderly condition and free from accumulated dust.

(4) Hatchery residue such as egg shells, infertile eggs and dead germs shall be disposed of promptly.

(5) Hatchers and hatching trays shall be cleaned and fumigated or disinfected after each hatch.

(b) A hatchery which keeps started poultry (poultry that has been fed or watered) must keep such poultry separated from the incubator room in a manner satisfactory to the Official State Agency.

(c) All poults offered for sale under Plan terminology shall be normal and typical of the variety, cross, or other combination represented.

(d) Eggs incubated shall be sound in shell and reasonably uniform in shape. Eggs shall be trayed, and poults boxed with a view to uniformity of size.

(e) All hatcheries within a State which are operated under the ownership or management of the same person or related corporation, or in which the same person or persons have a substantial financial interest as partners or otherwise, shall participate in the Plan if any of them are to participate. All hatching eggs or poults sold by such hatcheries shall be of the same pullorum-typhoid classification.

Breeding Stages

1. *U. S. Approved*—All males and females selected by Authorized Agents according to standards prescribed by the Official State Agency or the State College of Agriculture.

2. *U. S. Certified*—Flocks meeting one of the three following specifications:

(a) All males ROP or from ROP mass matings.

(b) Males and females from flocks composed of the following: ROP males or males from ROP mass matings mated to females from ROP qualified matings; or ROP mass matings; or ROP candidate matings in which 50 per cent or more of the dam's family qualified for ROP.

(c) Males and females from Performance Tested Parent Stock. In case the tested stock is a cross of strains, the U. S. Certified flock shall be a combination of the same pure strains as used in the tested flock.

3. *U. S. Record of Performance. Hens*—An ROP candidate hen which is a reasonably good representative of the variety in the judgment of the ROP Inspector, may qualify as an ROP hen if such candidate:

(a) Produces eggs at the rate of at least 50 per cent for a period of at least eight consecutive weeks from the date the first normal egg is laid in a trapnest; and

(b) Produces eggs that hatch at the rate of at least 70 per cent of all eggs set with a minimum of 20 poults hatched. The qualifying requirements for hatchability may be reduced to 65 per cent when eggs are hatched at altitudes of 3000 to 3499 feet and to 60 per cent at altitudes of 3500 feet or more. All normal eggs produced by the candidate during a period of at least eight consecutive weeks shall be set.

Toms—Toms may qualify for the ROP classification if they are:

(a) Produced from ROP poults or from candidate hens which subsequently qualify as ROP hens:

(b) Good representatives of the variety with strong constitutional vigor when examined by the ROP Inspector not earlier than 22 weeks of age; and

(c) Banded with an ROP sealed and numbered leg band when passed by the Inspector.

Pullorum-Typhoid Classes

1. *U. S. Pullorum-Typhoid Passed*—Flocks in which no pullorum or typhoid reactors are found on the last official blood test.

2. *U. S. Pullorum-Typhoid Clean*—Flocks in which no reactors were found on the first official blood test: Provided, that if reactors are found on the first test the flock may qualify with two consecutive official negative tests. In order to sell hatching eggs or poults of this classification, all hatching eggs and poults handled must be of this classification.

Blood Testing

(a) In the official blood test, the blood shall be drawn by an authorized agent or State Inspector and tested by an authorized laboratory, using either the standard tube agglutination or rapid serum test:

(b) There shall be an interval of at least 21 days between any official blood test and any previous test with pullorum-typhoid antigen.

(c) All turkeys to be used as breeders must be tested when more than four months of age.

(d) All domesticated fowl on the farm of the participant shall either be properly tested to meet the same standards as the participating flock or these birds and their eggs shall be separated from the participating flock and its eggs.

(e) All tests with Salmonella antigens of flocks participating in or candidates for participation in the Plan shall be reported to the Official State Agency within 10 days following the completion of such tests. All reactors shall be considered in determining the classification of the flock.

(f) Reactors may be submitted to a laboratory for autopsy and bacteriological examination. The laboratory and the number of reactors to be submitted shall be designated by the Official State Agency. In case bacteriological examination fails to demonstrate pullorum or typhoid infection, the flock shall be deemed to have had no pullorum or typhoid reactors. If other members of the Salmonella group are isolated, the Official State Agency may disqualify the flock for participation or require such other action as is deemed necessary with respect to the infection.

(g) After a flock has been classified by the Official State Agency, the results of any retesting of such flocks during the current breeding and hatching season shall not adversely affect its classification for the season, except that if in the opinion of the Official State Agency the amount of the reaction found in any flock is such as to be dangerous or detrimental to the operation

of the Plan, the Official State Agency shall require that such flock or flocks be retested after an interval of at least 21 days, or that use of such flocks as sources of eggs for participants be *immediately discontinued*. Furthermore, the Official State Agency may require that the hatching eggs from such flocks be removed from the incubator and destroyed prior to hatching.

Judging Turkeys for Exhibition, Live Market, or Dressed Quality

Until recent years the only shows for tukeys were the exhibition poultry shows. The realization that the winners in these exhibition shows were not necessarily the best market birds led to the establishment of shows where the live birds were judged for their market quality and also shows where dressed birds were exhibited. Renewed interest in turkey raising has also aroused an interest in the quality of poults and led to the day-old poult shows which are now held in some states.

Exhibition judging. While turkeys, like other species are judged generally by comparison, the score card (scale of points) gives the valuation for the different sections that should be considered by the judge.

Standard Scale of Points for Judging Live Turkeys

	Shape	*Color*	*Total*
Symmetry and Carriage	6		6
Condition	10		10
Weight	8		8
Head	3	1	4
Eyes	1	1	2
Throat—Wattle	1		1
Neck	3		3
Back and Spring Ribs	10	3	13
Tail	3	3	6
Wings and Shoulders	6	2	8
Breast and Keel	25	3	28
Thigh and Fluff	6	1	7
Legs and Toes	3	1	4
TOTAL	85	15	100

Live market classes. In many turkey shows the judges are emphasizing market quality instead of color pattern. Some shows have live market classes in which turkeys are judged almost exclusively for market quality.

Dressed turkey exhibits. Since the turkey is primarily a market bird sold to the ultimate consumer in the dressed condition and since the dressed market appearance of the bird cannot be judged always by looking at the live specimen, there have arisen the dressed classes for turkeys. They have served a very useful purpose in that they have educated producers to *market demands* and stimulated consumer demand for quality turkeys.

The National Turkey Federation Dressed Turkey Show

Basis for judging. The dressed turkey standard and scale of points, as prepared and adopted by the National Turkey Federation, are the official guides for the judges and the exhibitors at this show. These may be summarized as follows:

DRESSED TURKEY STANDARD

CONFORMATION	50
Depth of body, width of breast, length of keel, width of back and shoulders, legs moderately short.	
FLESHING AND FINISH	25
Fine texture and pliable skin, general covering with smooth coat of firm fat.	
MARKET APPEARANCE IN DRESSING	25
Cleanliness and body bloom. Free of abrasions, bruises, and improper bleeding. Freedom from pin feathers.	

The local show committee administers the National Dressed Turkey Show in accordance with the rules and regulations adopted by the National Dressed Turkey Show Policy and Coordinating Committee.

No one is allowed to handle any of the birds on exhibit, with the exception of the judges and show representatives.

All birds entered in the show must be frozen.

Incubation

Artificial incubation has, quite generally, replaced natural methods because (1) the time of setting can be controlled; (2) a larger number of poults can be hatched at the same time; (3) egg production of the breeding stock is higher, because the hens do not take time out to set; (4) there is less danger of transmitting disease to the poults; and (5) artificial incubation is less expensive than the natural incubation of turkey eggs, if all items of cost are considered.

Selection of hatching eggs. The reasons for making a selection of turkey hatching eggs are to improve hatching results, and to improve the quality of the poults produced. The only egg characteristic thus far found to be associated with hatchability is egg size. As in chicken eggs, it has been found that the very small eggs and the extremely large eggs do not hatch well. Extremely small eggs should be discarded because they produce undersized poults; but large eggs need not be discarded, because even though they may

not hatch well, they are worth more for producing poults than any other use which can be made of them. The Kentucky Agricultural Experiment Station has reported that poults hatched from these small and large eggs lack vitality, and the mortality among them is higher than among poults hatched from eggs of a more normal size. The average weight of eggs laid by Bronze hens during their first season's production is about eighty-five grams or three ounces. (Table 13–8.)

Table 13–8

WEIGHT OF TURKEY EGGS

Hens Laying	Number Hens	Per Cent of Total	Average	
			Grams	Ounces
Very small eggs—below 70 grams	4	1	67.00	2.36
Small eggs 70–79 grams	127	24	76.17	2.69
Medium-sized eggs—80-89 grams	298	56	84.01	2.96
Large eggs—90–99 grams	98	18	92.36	3.25
Very large eggs—100 grams and over	4	1	101.50	3.58
All hens	531	100	83.68	2.95

Small hens tend to produce smaller eggs than do larger hens. Eggs having abnormal shape and those with thin shells or cracked shells should not be used for hatching purposes.

Care of hatching eggs. The hatchability of the best hatching eggs can be destroyed by improper care while the eggs are being held before setting. The three factors most likely to reduce hatchability during this period are (1) abnormal holding temperatures, (2) holding the eggs too long, and (3) rough handling. Since the embryo undergoes development at temperatures above 82° F., hatching eggs should be held at lower temperatures. Work at the Kansas Agricultural Experiment Station (Table 13–9) showed that excellent hatching results were obtained when turkey eggs were held between 55° F. and 60° F. for as long as four weeks. Eggs held at high temperatures undergo some embryonic development and are thereby weakened so that the percentage of hatch is reduced. When eggs are held at low temperatures hatchability is reduced, though turkey eggs apparently resist cold better than do chicken eggs. Temperatures near freezing for a few days will completely destroy hatchability. The length of time turkey eggs can be held without reducing hatching results is very largely dependent upon the temperature at which they are held. It has been shown that rough handling, which causes the air cells to become tremulous, reduces the hatchability of chicken eggs. No doubt turkey eggs are affected in a similar manner. Turkey eggs while being

Table 13-9

EFFECT OF HOLDING TEMPERATURE AND AGE OF EGG ON HATCHABILITY OF TURKEY EGGS [1]

Days Held	Hatchability			
	Temp. 36° F. (1931)	Temp. 54° F. (1931)	Temp. 55–60° F. (1930)	Temp. 60–75° F. (1929)
1–6	66	71	89	72
7–13	52	65	90	73
14–20	27	75	85	45
21–27	6	67	84	14
28–34	0	61	86	6

[1] Kan. Agr. Expt. Sta. Bul. 276.

held before setting should be kept where the temperature is between 50° F. and 60° F. They should be held with the small end down in regular egg cases equipped with duck-egg fillers. Under the usual operating conditions they should not be held longer than two weeks. Turning by tilting the case is recommended if the eggs are held longer than one week.

Management of the Incubator

Poor hatches of turkey eggs are relatively more common than of chicken eggs. However, the cause is often found in the breeding stock or its management instead of in the incubation. There are, of course, incubation problems and the correct principles of incubation must be applied if satisfactory hatches of turkey eggs are to be obtained. Many turkey growers are purchasing poults or having eggs custom hatched, thus eliminating their problem of incubation. With good hatchable eggs the modern incubator when properly operated will give equally as satisfactory results when hatching turkey eggs as when used for hatching chicken eggs. The principles involved are the same but the requirements are slightly different.

Temperature. There are certain definite limits between which the temperature of the incubator must be kept if satisfactory hatching results are to be obtained with turkey eggs. Eggs incubated in forced-draft incubators hatch well when kept at from 99° F. to 100° F., if the other requirements for incubation are satisfied.

Humidity. For best results the relative humidity for incubating turkey eggs is near 60 per cent for the first twenty-four days and 70 per cent for the last four days. Such humidity conditions produce about the correct evaporation from the egg and provide satisfactory hatching conditions. To obtain the above relative humidities in forced-draft incubators the wet bulb reading

in such incubators should record for the first twenty-four days of incubation a temperature of 12° F. below the dry bulb temperature reading, and for the last four days of incubation the difference should be 9° F. Work at the Kansas Agricultural Experiment Station indicates that the optimum loss of moisture from turkey eggs while being incubated is about 3.0 per cent or less per week or from 11 to 13 per cent for the first twenty-four days of incubation.

Ventilation. Proper ventilation of the incubator and the incubator room are essential for successful hatches from turkey eggs. The developing embryos require air containing about 21 per cent oxygen and not more than 1.5 per cent carbon dioxide. Since the oxygen requirements of the embryos increase as they develop, it is evident that ventilation must be increased as the hatch progresses. Any increase in ventilation tends to reduce the relative humidity of the incubator. For best results at hatching time the incubator must be well ventilated and the humidity kept high.

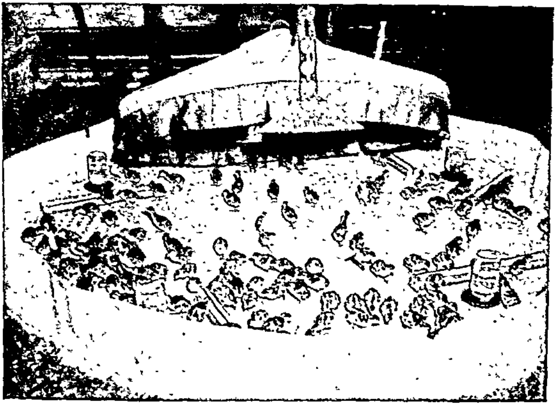
Turning. For satisfactory hatches turkey eggs must be properly turned while being incubated. With machines equipped with turning devices which require but little labor, the eggs should be turned at least five times daily. Developing embryos are sensitive organisms and therefore the turning of eggs or shifting of their position should be done with a minimum of jarring.

Handling newly hatched poults. The newly hatched poults should not be exposed to temperatures lower than their hatching compartment until they have dried off. After they are "fluffed out," they may be placed in boxes where the temperature is lower so that they may "harden." The bottom of the box or tray should be covered with material which will prevent slipping and therefore the straddling of the legs. Poults may be held or shipped in regular chick boxes, placing from fifteen to eighteen poults in the compartments designed for twenty-five chicks.

The production and sale of day-old poults. The production and sale of day-old poults has during the past few years made rapid progress. Turkey producers appear to be following the lead of poultry raisers who have quite largely turned to the purchase of day-old chicks instead of doing their own hatching. Many large turkey producers maintain breeding flocks which they use for producing poults for their own use and hatching eggs or poults for sale. The development of hatcheries which specialize in poult production has created a demand for turkey-hatching eggs which has stimulated the growth of hatchery supply flocks. The commercial production of day-old poults may be expected to increase, and such producers become the source of supply of most poults.

Brooding

Within the last fifteen or twenty years turkey raising has become highly commercialized and many growers now raise several thousand birds annually. Such large-scale operations are possible now because practical methods of artificial incubation and brooding have been developed (Fig. 13–8).



COURTESY "TURKEY WORLD"

Fig. 13–8. Starting poults with an electric brooder. Note feed placed on egg-case filler flats to encourage eating the first few days. Small feeders and waterers for young poults are in place.

Brooding Requirements for Turkeys

Successful brooding of poults depends upon satisfying all of the essential requirements of the poults at this stage of their development. The environmental conditions necessary for satisfactory growth during the brooding period are proper temperature, adequate ventilation, sanitary quarters, and sufficient room.

Temperature. The environmental temperature for poults must be controlled so that they are kept comfortable during the brooding period. For the first few days they should be confined by means of a guard near the source of heat so that they may learn where to go later to become warm, after the guard has been removed. Before the poults are placed under the hover, the temperature should be adjusted to about 95° F. two inches above the floor at the edge of the hover of a fuel-burning brooder or under the hover of an electric brooder. The temperature should be reduced about 5° F. each week until heat is no longer needed. After heat is no longer needed during the day, it will be needed at night to prevent chilling and piling.

Ventilation and humidity. Fresh air is necessary for normal growth and development. Ordinarily, a brooder house with an open front which has a muslin curtain for use in cold or windy weather will provide sufficient ventilation. Faulty brooder stoves when operated in tightly closed brooder houses

sometimes cause carbon monoxide poisoning of poults. The condition of the air in a brooder house can be judged best when one first enters it. Foul air generally can be detected by odors.

Proper ventilation will help prevent dampness in the brooder house. One indication of poor ventilation in the brooder house is dampness. The brooder house should be kept reasonably dry at all times. However, an excessively dry brooder room causes poor feather growth and should therefore be avoided.

Sanitation. The prevention of disease in turkeys depends quite largely on the sanitation program followed. The brooder and all equipment used should be cleaned often and kept in a sanitary condition at all times.

Floor space. It is false economy to overcrowd poults in the brooder house. A good rule to follow is to allow for the first eight weeks at least one square foot of floor space for each poult. Each poult should also be provided with from 10 to 14 square inches of space beneath the canopy of the brooder stove. A brooder stove with a 52-inch canopy will provide room for 150 poults.

Brooding Equipment

The equipment needed for brooding poults is quite similar to, and in many instances the same, as that used for brooding chicks.

Houses. Movable colony brooder houses and permanent brooder houses are both used for brooding poults. A 10′ x 12′ colony brooder house will provide room for starting and brooding to eight weeks of age 125 poults. Permanent brooder houses are generally used by commercial turkey growers.

Brooder stoves. Any brooder suitable for chicks (Fig. 13–8) can be used for starting poults. Colony brooder stoves are used in the small movable brooder houses and also in the individual pens of the long, permanent houses. Hot water brooding systems are very desirable for the long houses with many pens. Battery brooders are being used successfully by some producers for brooding poults as long as they need heat (Fig. 13–10).

Feeders and waterers. Poults should always have an opportunity to eat or drink when they so desire. The feeders and waterers used for chicks are satisfactory for poults. For the first eight weeks each poult should be provided with two inches of feeding space at such feeders. One fountain (one gallon size or larger) should be provided for each fifty poults. Both the feeding and watering space should be increased as the poults grow into larger birds.

Roosts. Roosts should be placed in the brooder house by the time the poults are three or four weeks old. These roosts should be 1″ x 2″, 1″ x 3″, or 1″ x 4″ laid flat and built on frames about one foot high, with poultry netting beneath them to prevent the poults from falling from the roosts and to keep them away from their droppings.

Brooder Management

Success in brooding turkeys depends quite largely upon the good judgment of the operator. The management practices followed are most important.

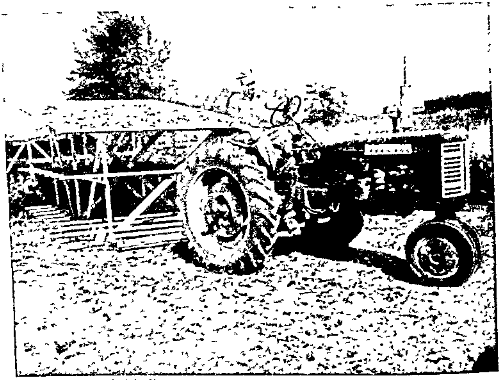
Fig. 13-9. Starting poults in a battery brooder reduces labor to a minimum and prevents early brooding troubles, such as piling.

Providing brooding requirements. The requirements listed above must be provided. The poults must be kept comfortable regardless of outside weather conditions; the brooder room must be adequately ventilated; sanitary quarters must be maintained; the birds must be provided with plenty of room; and they must be properly fed.

Litter for poults. Litter is essential for maintaining a sanitary brooder house floor, unless batteries are used. For the first two weeks, coarse sand, gravel, peat moss, or other suitable litter is recommended. It is well to cover the litter with paper while teaching the poults to eat, so that they do not consume too much litter before they learn to find their feed. Later, coarser litters such as straw, shavings, or ground corncobs may be used. Wire floors are used by some producers. One-inch mesh wire floors covered with one-half-inch mesh hardware cloth for the first two or three weeks provides a very sanitary floor. Such floors are expensive and often inconvenient to move.

Educating the poults. One problem which taxes the beginner's ingenuity is that of teaching poults to eat. Some use rolled oats, others milk or clabber, and others finely chopped boiled eggs or green feed. Some producers place a few older poults or some day-old chicks with the poults to teach them to eat. Some growers dip the poult's beak in water and feed as they place them in the brooder house.

When placed under a canopy brooder, the poults should be confined by



COURTESY UNIVERSITY OF MISSOURI

Fig. 13–10. Range shelters being moved to clean ground.

a guard such as shown in Figure 13–9. This will teach the poults where to go to become warm. All corners should be rounded off to prevent piling. Poults should be taught to roost early as this will prevent piling at night.

Rearing Turkeys

Raising or growing turkeys after they no longer need heat and the protection of a brooder house is a necessary part of any turkey production program.

Confinement versus Range for Market Turkeys

The raising of turkeys in complete confinement is more common now than a few years ago. Some advantages are (1) less loss from predators and adverse weather, (2) less labor required, and (3) closer supervision of the birds.

The disadvantages are (1) greater investment in buildings, (2) difficulty in controlling outbreaks of disease, (3) poor feathering which hinders picking at the processing plant and results in a less attractively dressed bird, and (4) bruised and torn backs. For these reasons, processors prefer birds raised on the range.

Confinement is necessary if only a limited acreage is available or if the range is contaminated.

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Fig. 13–11. Turkeys browsing on milo.

If range is used the turkeys should be limited with fences so that the range may be rotated (Fig. 13–10). Turkeys will remain near feed and water. Growing pasture on range will supplement the ration and reduce feed costs.

In experiments at the University of Missouri, it was found that turkeys on range with mature milo available, made slower growth than turkeys on full feed in sod pasture (Fig. 13–11). The amount of mash required was about the same but the grain fed in feeders (corn) could be completely eliminated (Table 13–10).

Missouri also reported another test in which turkeys 16 to 20 weeks of age feeding on milo pasture consumed 2.49 pounds of a 20% protein mash per pound of gain, and from 20 to 24 weeks of age, ate only 1.93 pounds of mash per pound of gain. It should be noted that turkeys feeding on milo pasture need about two weeks longer than others until ready for market.

Table 13–10

FULL AND RESTRICTED RANGE FEEDING 18–24 WEEKS *

	Turkeys on full feed on sod pasture	Turkeys on milo range (other grain restricted)
Mash (21% protein) consumed	3355 lbs.	3625 lbs.
Corn consumed	8968	448
Total feed consumed from feeders	12323	4073
Total gain.	2349.7	1673.5
Lbs. feed (mash & corn) per lb. gain.	5.24	2.43
Mortality (%)	1.9	2 0
Avg. gain in wt. by males from 18 to 24 weeks.	7.72	5.72
Avg. gain in wt. by females from 18 to 24 weeks	3.42	2.85

* Univ. Mo.

Range shelters and roosts. Some growers use range shelters as roosting quarters for turkeys. In some cases roosts are provided on the roof of the range shelter as well as under the roof. Poults can be moved to range earlier if range shelters are used than if they have to roost in the open without any protection against the weather.

Roosts are generally used but are not absolutely necessary for turkeys. Some growers roost their turkeys on the ground. Investigations reported by the Wyoming Agricultural Experiment Station showed that four-inch poles were satisfactory roosts for growing turkeys. Two-by-fours laid flat and slightly tilted are good roosts. Narrow roosts increase the number of dented breastbones. Some producers build roosts on wheels so that they can be moved easily. Roosts placed on saw horses are satisfactory and can be moved easily. The roosting quarters, if permanent for the season, should be so arranged that the turkeys cannot get to the droppings.

Yards for growing turkeys. Where a small number of turkeys are raised, it is advisable to confine them to limited range by using temporary yards. One acre of land on which there is good growing green feed will provide enough range for 125 turkeys to market age. Movable fences, such as are generally used as snow fences along highways, make very good temporary fences for yarding turkeys. They should be moved about every two weeks and so arranged that about one-fourth of the acre is in the yard.

Shade. In most sections of the United States turkeys need shade during the summer months. Trees and growing crops such as corn, grain sorghums, and sunflowers provide the best shade for turkeys. But if such shade is not available, artificial shade should be provided.

Protection against predators and thieves. Well-constructed wire fences will protect turkeys against dogs, wolves, and coyotes. Flares arranged near the roosts will scare most animals away, as well as thieves.

Feeding Growing Turkeys

Growth of turkeys. The growth rate of turkeys is higher than that of chickens, and as in chickens, growth is influenced by a number of factors. The producer of turkeys is interested in a relatively high rate of growth throughout the growing period so that economical gains may be obtained up to the age when the birds are marketable. A comparison of the sizes of turkeys of different strains at various ages as presented in Table 8–8 shows wide differences. Heredity, therefore, is an important factor influencing growth.

The ration used influences the rate of growth; however, the mature body weight is not materially different if the rations used maintain the health of the turkey. High protein rations produce more rapid early gains, but the adult turkeys at twenty-eight weeks of age are about the same size as those grown on a lower protein level.

The weather is also a factor influencing growth. Turkeys grow slowly during hot weather, but later compensate for such retarded growth so that the mature body weight is about the same as if they had not been exposed to high temperatures.

Nutritive requirements for growth of turkeys. The nutritive requirements of the turkey (Tables 8–4 and 6 and 13–6) are similar to those of the chicken but vary in some respects. The turkey is quite sensitive to nutritive deficiencies and the wise producer will use reliable rations as developed by the experiment stations and the commercial feed manufacturers.

Protein requirements. The turkey requires a high protein ration for the first few weeks when the rate of growth is high. But as the rate of growth diminishes and the birds approach maturity, the protein content of the ration may be reduced (Table 8–4). Work done at different stations on this subject indicates that a ration containing 28 per cent protein for the first six weeks, 20 per cent for next six weeks, and thereafter reduced to 15 or 16 per cent, by allowing the birds to choose mash or grain, provides the growing turkey with sufficient protein if that protein is of suitable quality. Meat scrap, fish meal, dried buttermilk, dried skim milk, and soybean oil meal are all suitable protein concentrates for turkey rations.

Vitamin requirements. Turkeys have higher vitamin requirements than chickens and therefore their rations must be well fortified with vitamins (Table 13–6).

Mineral requirements. Though it is apparent that turkeys must receive in their rations all of the mineral elements necessary to sustain life and stimulate normal development, it is equally apparent that these elements are present in sufficient quantities in otherwise well-balanced rations if the birds have access to range so that no special mineral supplements are needed. For proof of this, witness the turkeys raised by a turkey hen on range. The principal mineral elements needed by turkeys are calcium, phosphorus, sodium, chlorine, manganese, iron, iodine, potassium, and magnesium. But even under the conditions of commercial production, only the first five of these need be fed as special supplements (Table 13–6). Bone meal supplies calcium and phosphorus, salt supplies sodium and chlorine, and manganese sulphate may be used as a source of manganese. (For a more detailed discussion of minerals see Chapter 8.

Energy requirements. Normal body activity and functions require energy for maintenance, growth, and egg production (Table 8–4). Fats, proteins, and carbohydrates may serve as sources of energy. Such carbonaceous feeds as the grains are the principal sources of heat and energy in the ration.

Water requirement. Water is one of the most important nutrients for animal life. It constitutes by weight more than 50 per cent of the young growing turkey, makes digestion and absorption possible, is an important constituent of the blood and lymph and thereby serves as a carrier of the nutrients and waste products of the body, and it aids the body in temperature regulation by providing a means of evaporation.

Rations for growing turkeys. To promote satisfactory growth in turkeys the rations (Table 13–7) must satisfy the nutritive requirements previously discussed. Fortunately these requirements can normally be satisfied with simple mixtures, if the turkeys have access to range where there is growing green feed.

Turkeys raised on range where there is growing green feed consume less mash and grain per pound of gain because they consume considerable quantities of green feed. Results reported by the Indiana and the Oregon Agricultural Experiment Stations show that male turkeys utilize feed more efficiently than female turkeys from the eighteenth to twenty-eighth weeks (Indiana) and twenty to thirty-two weeks (Oregon).

In studies which have been made at the Missouri Station, it has been found that males make more efficient gains than females after the 16th week of age and that from 17 to 30 weeks of age the males require both less protein and carbonaceous nutrients per pound of gain than are required by females during the same period. These data are of course limited to the periods covered.

Feed consumption of turkeys. The feed consumption of growing turkeys increases from about one and one-half pounds per bird during the first month (four weeks) to approximately twenty pounds during the seventh month (Table 8–8). The proportion of mash and grain which turkeys will consume, if they have their choice, varies with the protein content of the mash (Table 13–11). Evidently turkeys as well as chickens have the ability to

Table 13–11

RATIO OF MASH CONSUMPTION TO GRAIN CONSUMED BY GROWING TURKEYS *

Approximate Percentage of Crude Protein in the Diet	Proportion of Mash to Scratch Consumed During the Brooding and Rearing Period											
	1–4 Weeks	5–8 Weeks	9–12 Weeks	13–16 Weeks	17–20 Weeks	21–24 Weeks	25–28 Weeks	29–32 Weeks	1–24 Weeks	1–28 Weeks	1–32 Weeks	9–28 Weeks
18	96:4	97:3	90.10	97.3	90.10	67:33	39.61	...	85:15	74:26	...	77:23
20	94 6	97:3	87:13	87:13	71:29	46:54	30:70	..	72:28	61:39	.	64·36
22	92.8	94 6	85.15	89:11	67:33	47:53	30:70	24:76	72.28	62:38	54:46	64:36
24	84.16	88:12	74:26	77 23	65.35	48.52	30:70	20.80	67·33	58:42	54:46	59.41
26	91:9	86 14	79·21	77:23	61:39	39.61	27:73	.	63:37	54:46	...	57:43
28	87·13	82:18	72:28	70 30	54 46	33.67	25:75	...	57:43	49·51	...	51:49
30	84:16	81.19	70.30	63:37	48:52	28:72	26:74	..	53:47	46:54	...	47:53

* Data from *Turkey Management*, by Marsden and Martin, 1939. By permission of The Interstate Printers and Publishers.

choose feeds which satisfy their requirements at a particular stage of development.

Efficiency of gains made by turkeys. Turkeys are efficient meat-producing animals. During the first twelve weeks of their lives, turkeys will increase their body weight by one pound for each three pounds or less of feed consumed (Table 8–8). After the third month, the feed required to produce a pound of gain increases rapidly, rising to above seven pounds during the seventh month and as much as ten pounds for the eighth month. The turkey

producer is interested in the amount of feed required to produce a pound of marketable turkey.

Marketing Turkeys

Since turkey production is highly seasonal and the producing areas are located far from the largest cities (Fig. 13–13) the marketing of turkeys constitutes a major problem and sometimes taxes the facilities of the existing marketing agencies.

Seasonal production. The turkey remains primarily a holiday bird; and fortunately, conditions in the major producing areas are such that the bulk of the turkey crop can be matured and finished most economically for the Thanksgiving and Christmas markets. While turkeys can be grown for marketing during any month of the year (Fig. 13–14), climatic conditions in the United States are most favorable for producing a turkey crop for marketing late in the fall and during the winter. Most of the turkeys consumed out of this natural marketing season are dressed birds which have been held under refrigeration. The quality of these birds is usually superior to the freshly killed turkeys at that time. The proportion of the turkey crop marketed by months varies somewhat from year to year. If turkey prices advance from Thanksgiving to Christmas, the following fall there is a tendency for the producers to hold turkeys for the Christmas market. If warm weather prevails during the fall months in the large producing areas, the birds will be slow in finishing, and therefore a larger proportion of the crop will be marketed late.

Table 13–12 shows the proportion of turkeys marketed by months. There

Table 13–12

TURKEY MARKETINGS: PROPORTION OF CROP (EXCLUSIVE OF BREEDERS) MARKETED IN SPECIFIED MONTHS, UNITED STATES. 1953

Geographical Divisions	Before Aug 1	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. or later
North Atlantic.........	5.8	3.5	5.6	8.2	38.0	30.8	8.1
East North Central. ...	3.6	4.8	10 0	16.1	37.8	23.1	4.6
West North Central. .	10.3	8.2	13.1	21.1	27.0	17.1	3.2
South Atlantic....... ..	16.9	10.4	14.4	12.5	26.7	16.7	2.4
South Central..........	3.2	2.3	24.4	12.5	28.4	24.2	5.0
West....................	8.0	6.1	13.5	16.9	29.9	19.1	6.5

is a growing tendency to market turkeys throughout the year, but the bulk of the crop continues to be marketed in November and December.

Turkey Production and Consumption in the United States. The number of turkeys produced in the United States increased from 31 million in 1948 to 78 million in 1958. The per capita consumption increased from 3.6 pounds to 5.6 pounds during the same period. The midwestern states produce a surplus of turkeys while most other regions have a shortage (Fig. 13–12).

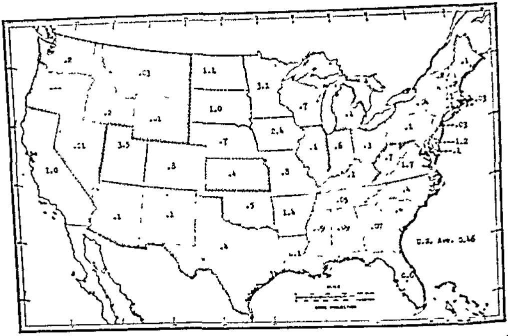
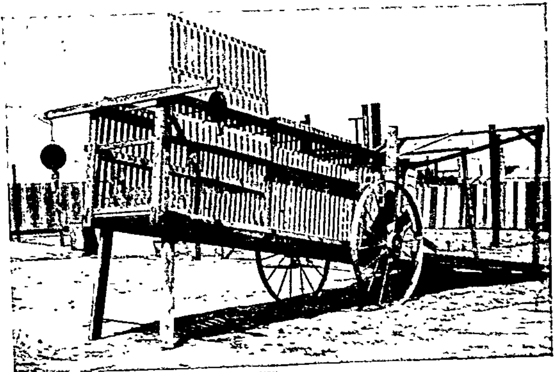


Fig. 13–12. Turkeys raised ÷ by population. 1958. States below the U. S. average (0.46) and shaded are deficit areas.

The per capita consumption per person in 1958 amounted to only 0.46 turkey.

Selecting birds for market. Many turkey growers sell their entire crop at one time and sometimes before all the birds are ready for marketing. Birds lacking finish or having immature plumage should be held until they will dress into good market specimens. Only fat turkeys free from pinfeathers command the best prices. Immature turkeys lacking finish are frequently sent to market, where they sell for less than the cost of producing them. If these birds had been kept by the producer until they were mature and finished they would have commanded higher prices and returned a profit to the grower. While it is more difficult to grade live turkeys than the dressed birds, an experienced turkey raiser can select those birds which are finished. The birds which are ready for market have mature plumage; they are well-fleshed, as shown by a well-covered breast, pinbones, and back; and they are well covered with fat, as shown by a light cream-colored skin on the breast. Some turkeys, such as those with extremely crooked breastbones and deformed backs, should be used at home instead of being sent to market. By selecting for market only those birds which are finished, the grower can increase his net returns from turkey raising.

Catching market turkeys. The producers of turkeys lose thousands of dollars annually because of bruised carcasses resulting from improper handling while the birds are being caught and cooped. Much of this damage can be avoided by the use of some simple equipment and by handling the birds carefully. For small flocks the best procedure seems to be to drive a few birds at a time into a small pen and pick the birds up by grasping them by



COURTESY CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Fig. 13–13. Catching, grading, and loading chute.

the wings near the body, instead of grabbing them by the legs and throwing the birds on the floor or ground and thereby bruising the breast.

Where large flocks are raised a catching chute is indispensable. Figure 13–13 shows a movable catching chute. The birds can be driven into such a chute and rapidly caught without bruising or otherwise damaging the turkeys. Producers who have changed to the use of the catching chute from less efficient methods report a marked improvement in the quality of the birds they market, because bruises have been practically eliminated.

Methods Used in Marketing Turkeys

Turkeys are sold by producers direct to consumers, to local buyers, and to commission merchants, in co-operative pools and through packers on a custom dressing basis.

Direct marketing. Since most turkeys are raised far from the large centers of population, only a very small percentage of the turkey crop is sold by the producer to the consumer. However, in some cases very profitable outlets have been developed by producers who sell dressed turkeys direct to the consumers. Such direct sales necessitate the dressing of the birds by the producer or custom dressing at a local killing plant. Some producers have developed a mail-order business and ship the dressed turkeys by parcel post or express.

Local buyers. In the Middle West, most of the turkeys are sold alive to the central packing plants. The birds are trucked to these central plants where they are killed and otherwise prepared for market. Storekeepers who were once important purchasers of both dressed and live turkeys are no longer

important marketing agencies. Local poultry buyers who purchase both poultry and eggs purchase some turkeys from the nearby producers and send them to the concentration packing plants. Most turkeys are now picked up at the farm by trucks.

Losses in preparing turkey for consumption. The losses vary with the strain, size, and finish. Small birds have a higher percentage of shrinkage than large ones. The range varies from about 18 to 25 per cent resulting from loss of blood, feathers, head, feet, shanks, and inedible viscera (Table 7–Appendix). Turkeys provide a higher percentage of cooked edible meat than other species of poultry (Table 9–Appendix and Fig. 13–15).

For estimating prices for blood- and feather-dressed turkeys and for full-drawn birds, the producer may assume that for each 100 pounds of live turkey there would be 90 pounds after blood and feather dressing and about 75 to 80 pounds after the birds were full drawn. This loss in weight plus the cost of dressing (Table 12–33) and drawing would have to be charged to the dressed and drawn birds.

Cooling. Failure to properly cool dressed turkeys results in lower quality, and sometimes the birds become unfit for food. The internal body temperature of the birds should be lowered to at least 40° F. before they are packed in boxes. This will require from twelve to twenty-four hours cooling (Fig. 11–21) after dressing. Government graders are not permitted to grade turkeys unless the birds have been precooled to 40° F. or unless the grader supervises the cooling after grading.

Grades and grading. Turkeys are more generally graded and sold according to the federal grades than are chickens (Table 13–14).

Table 13–13

RESULTS OF THE TEXAS RANDOM SAMPLE TURKEY MEAT PRODUCTION TEST 1958.

	B B B. Breeder Replacement Entries	B B. Bronze Commercial Entries	B B.B. Strain Cross Entries	B B. White Breeder Replacement Entries
Percentage Hatch of all eggs	53 0	57.2	47.4	56.2
Mortality to 26 wks.	8.7	8.4	5.5	8.9
Live wt. hens (22 wks)	14 6	14.5	14 8	13.4
Live wt. (26 wks)				
Range toms	26.7	27.4	26 9	25.3
Confinement toms	25.8	26.3	26.3	24.1
Dressing percentage				
Hens (22 wks)	81.1	79.9	80.6	79.2
Toms (26 wks)	82.3	82.7	82.8	82.1
Feed conversion				
Hens (22 wks)	3 44	3.45	3.50	3.41
Toms (26 wks)	3.56	3.51	3.54	3.59
Grade A				
Hens (22 wks)	97.5	96.6	98.5	97.9
Toms (26 wks)	90.5	92.3	96.1	93.4

Cost of Producing Turkeys

The cost of producing turkeys (Table 12–32) influences greatly the profits from raising market turkeys. A Missouri study on 64 flocks showed the cash cost distribution as follows: feed, 77.8 per cent; poults, 16.9 per cent; and other cash costs, 5.3 per cent.

Turkey Diseases

The prevention and control of diseases and parasites is necessary if turkey raising is to be profitable. Major shifts of the industry have occurred because of the ravages of disease. Turkey raising, once an important industry in the East and Middle West, was almost completely abandoned in many areas because of losses from blackhead. The industry shifted to the West and Southwest where climatic conditions were more favorable for the control of blackhead. New discoveries made in recent years on the prevention and control of blackhead have made turkey raising again profitable in the East and Middle West, and the industry appears to be shifting to those areas which are nearer the principal markets.

The control of turkey diseases and parasites depends primarily on sanitation. The essentials of a sanitation program for raising turkeys may be briefly summarized as follows: Grow clean poults in clean houses with clean feed and water, and maintain clean range where the poults are raised. Such a program implies much but it will insure healthy turkeys.

If an outbreak of disease occurs, someone properly trained and familiar with the diseases of turkeys should be consulted at once. The veterinary departments of the state colleges of agriculture and state departments of agriculture are generally equipped to diagnose turkey diseases and advise as to the control measures which should be applied (See Chapter 9).

Mortality in Young and Adult Turkeys

Though the death loss in both young turkeys and among breeding stock has been declining in recent years losses are still too high, especially in young stock grown to market age. Those who can keep these losses below 10 per cent (Table 13–13) will find turkey raising more profitable than those who experience heavier losses. The control of losses from diseases and parasites is essential to success in growing turkeys.

Blackhead. This disease probably causes greater losses in turkeys than all other diseases (Fig. 9–14 and 15). It is caused by a protozoan organism which may be carried by either chickens or turkeys. The blackhead organism will live only a few hours outside the fowl's body unless contained within cecal worm eggs, in which case it may survive and remain infectious for turkeys for several months. Young turkeys less than three months old are most susceptible to attacks of this disease. The disease affects the liver and the most

Table 13–14

SUMMARY OF SPECIFICATIONS FOR STANDARDS OF QUALITY FOR INDIVIDUAL CARCASSES OF DRESSED AND READY-TO-COOK TURKEYS

[MINIMUM REQUIREMENTS AND MAXIMUM DEFECTS PERMITTED]

Factor	A Quality		B Quality		C Quality
Conformation	Normal		Practically normal		Abnormal
Breastbone	Slight curve, ¼" dent		Dented, curved, slightly crooked		Seriously crooked } If fairly well fleshed
Back	Normal (except slight curve)		Moderately crooked		Seriously crooked } If fairly well fleshed
Legs and wings	Normal		Moderately misshapen		Misshapen
Fleshing	Well fleshed, moderately long and broad breast.		Fairly well fleshed on breast and legs.		Poorly fleshed
Breastbone	Not prominent		Not prominent		May be prominent
Pouchiness	Slight		Definite		Extended
Fat covering	Well covered—some fat under skin over entire carcass. Fryers and young toms only moderate covering.		Sufficient fat on breast and legs to prevent a distinct appearance of flesh through skin.		Lacking in fat covering over (all parts of carcass)
	Breast and legs	Elsewhere	Breast and legs	Elsewhere	
Pinfeathers:					
Dressed: Pins and hair	Practically free	Practically free	Relatively few	Slight scattering	Numerous
Ready-to-cook:					
Nonprotruding pins and hair	Practically free	Practically free	Few scattered	Few scattered	Scattering
Protruding pins	Free	Free	Free	Free	Free

Cuts and tears:[1]	Free	3 inches	3 inches	6 inches	No limit
Missing skin[2]	None		3 areas none of which exceed 1", total aggregate 1½".	Width of feather tract tail to hips.	No limit
Disjointed bones	1		2		No limit
Broken bones	None		1 nonprotruding		No limit
Missing parts	Wingtips		Wingtips and if ready-to-cook 2d wing joint and tail.		Wingtips and if ready-to-cook, wings and tail
Discolorations:[3]	*Inch*	*Inch*	*Inch*	*Inch*	
Flesh bruises	0	1	1	3	No limit[4]
Skin bruises	¼	1½	1½	3	No limit[4]
All discolorations	2	3	3	6	No limit[4]
Freezer burn	Few small (⅛-inch diameter) pockmarks.		Moderate-dried areas not in excess of ½-inch in diameter.		Numerous pockmarks and large dried areas

The quality designations specified herein are not applicable to birds possessing any of the following conditions. dirty or bloody head or carcass, dirty feet or vent, feathers, or feed in the crop or crop cavity

[1] Total aggregate length of all cuts and tears including incision for removal of the crop or its contents.

[2] Total included in permitted tears and cuts

[3] Maximum diameter of aggregate areas of all flesh bruises, skin bruises, and discolorations

[4] No limit on size and number of areas of discoloration and flesh bruises if such areas do not render any part of the carcass unfit for food.

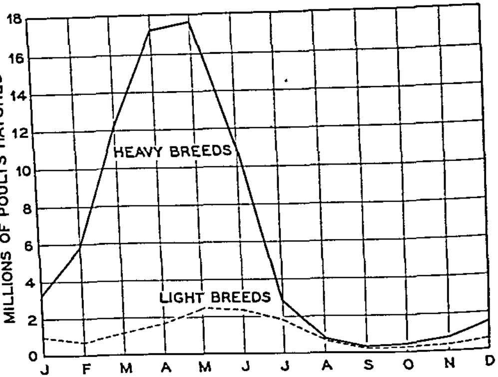


Fig. 13–14. Number of poults hatched during year.

noticeable symptom, found when turkeys having blackhead are killed and examined, is an enlarged liver covered with sunken ulcerlike areas. Poults raised by artificial methods, away from chickens and old turkeys on ground where neither turkeys nor chickens have ranged or their droppings have been spread during the past two years, seldom suffer from blackhead. If an outbreak of blackhead occurs, the best program to follow appears to be as follows: (1) Remove all sick birds from the flock, and either kill or confine these birds away from the healthy birds; (2) Clean the houses, thoroughly scrubbing them with hot lye water; (3) If convenient, confine the flocks to houses and wire-floored sun porches for several days, cleaning the house daily; and (4) Move the healthy birds to clean range. If the birds are too large to be confined in brooder houses, they may be moved directly to clean range. There are drugs available that are helpful in treating this disease (p. 316).

Pullorum disease. Turkeys have probably been infected with pullorum disease by their association with chickens. Many flocks of turkeys are, as yet, free of the disease and until recent years very few reactors were found in turkeys. It has been shown that poults hatched in incubators with chickens which have pullorum disease also suffer outbreaks of this disease.

Turkeys which have pullorum disease may be detected by the tube agglutination test.

This disease in turkeys can be controlled by testing the breeding stock and removing all reactors to the disease, then incubating the eggs either away from

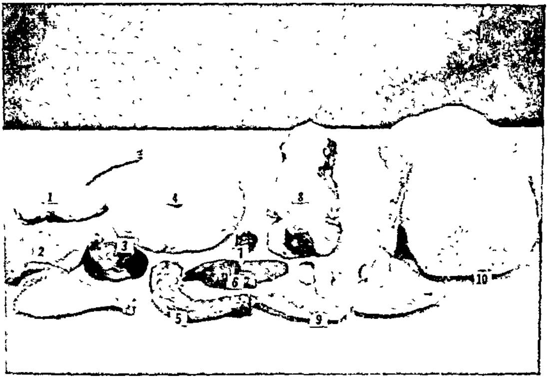


Fig. 13–15. Cut-up parts of a turkey (see Table 7, Appendix).

chicken eggs or only in incubators where chicken eggs from flocks tested for pullorum disease are hatched.

Coccidiosis. Though turkeys do develop coccidiosis, they are not so susceptible to this disease as are chickens. Methods of control and the symptoms of the disease are quite similar to those described for chickens. (See Chapter 9.) The organism causing coccidiosis in chickens does not cause coccidiosis in turkeys, and vice versa. The most effective method of control appears to be daily cleaning for several days after an outbreak of coccidiosis so that the organisms cannot undergo the twenty-four-hour incubation period outside of the body of the turkey which is necessary for them to become infectious.

Several effective drugs are now available for preventing and treating outbreaks of coccidiosis.

Trichomoniasis. This disease, because the symptoms are somewhat similar, may be confused with coccidiosis. It is only within recent years that trichomoniasis has been recognized as a distinct disease of turkeys and the causative organism identified. This disease usually affects poults from six to ten weeks of age. The most common symptoms are listlessness and yellow, foamy, and semi-liquid droppings. The California Agricultural Experiment Station in 1937 made the following recommendations for the prevention and control of this disease.

1. Avoid all contact of poults with chickens and adult turkeys.
2. Brood by artificial means on new ground or with brooder equipment having cement floor or wire platforms in both the houses and yards. Purchase, if possible, the entire brood at one time and early in the season.

3. Use a sane, sound management program. The brand of feed is of little importance. If the feeding method used in previous years was successful, stick to it.
4. Keep visitors out of the brooding pens.
5. Do not visit the turkey yards of any other grower. Discuss your problems with him on the street corner or at his home, not in his turkey yard.
6. If disease breaks out, get an accurate diagnosis. Send or take some of the sick specimens to a diagnostic laboratory, and do not accept a field diagnosis until it has been confirmed by the laboratory.
7. Avoid all drastic treatment until the laboratory diagnostic report is received. The treatment should then be based on the laboratory findings.

Other diseases and parasites. Turkeys are afflicted with many of the other diseases and parasites of chickens, which are described in Chapter 9. Some of the more common of the other diseases which affect turkeys are botulism, fowl cholera, fowl pox, colds, roup, fowl typhoid, and tuberculosis and paratyphoid. Turkeys are infested by cecum worms, gapeworms, roundworms, and tapeworms. They are attacked not only by lice but also by mites and ticks.

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Chapter 14

Ducks, Geese, and Miscellaneous Poultry

WHEN SPEAKING OF THE POULTRY INDUSTRY, one generally has chickens in mind. In the preceding chapter, the increasing importance of the turkey industry was pointed out. There are other species of birds classed as poultry that are of considerable economic importance. The chief ones among them are ducks and geese. Pigeons and guineas are also of some importance.

Ducks

The duck industry. According to the 1955 census, there were 11 million ducks raised in the United States in 1954. The industry has just about held its own during the last thirty years.

The greatest numbers of ducks are raised in the following states, listed in order of production: New York, Michigan, Illinois, Massachusetts, Wisconsin, Pennsylvania, California, and Ohio. Commercial duck raising has been developed most extensively in New York. The number of ducks kept, in proportion to the total population, is much lower in the United States than in most other countries. The relative number in Great Britain, Ireland, and New Zealand is several times larger than in this country.

Intensive duck farming on a large scale has been more successful than intensive chicken raising (Fig. 14–1). Ducks stand confinement well, are more easily brooded, and are less subject to disease than are chickens.

Ducks are raised primarily for meat purposes. They are especially adapted for this on account of the rapidity of growth (Table 8–8), hardiness, and ease of handling. Duck raising, as a business, is limited, for the demand for duck meat is not so steady nor its popularity so great as for chicken. Summer resorts and large cities with a foreign population make the best markets.

The demand for duck eggs is very limited. They are larger than chicken eggs, but bring about the same price or less. They find some use in the baking industry.

Breeds of ducks. There are eleven standard breeds of ducks which have been admitted to the American Standard of Perfection. Most of them have descended from the mallard, or wild duck, which is widely distributed, ranging from eastern Asia to North America. The duck was first domesticated in Asia. The ancestors of most of our present breeds were imported from there

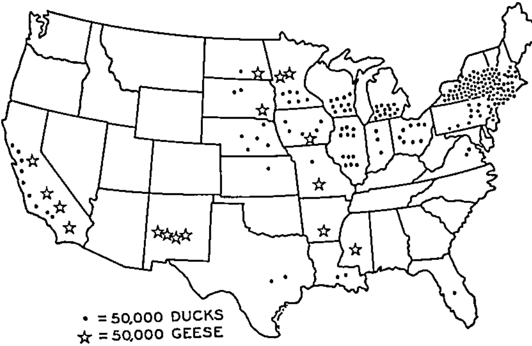


Fig. 14–1. Duck farming is concentrated in the East.

The breeds of ducks may be divided into meat, egg, and ornamental classes.

The meat class includes the Pekin, Aylesbury, Muscovy, Rouen, Cayuga, Buff, and Swedish breeds.

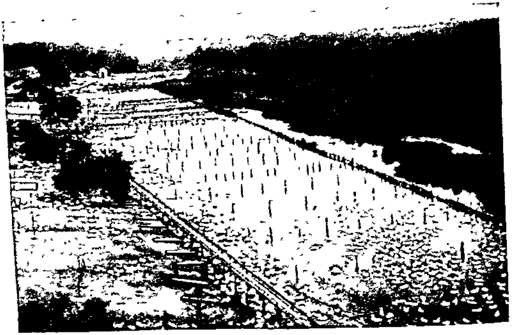
The Pekin is by far the most popular. It was introduced from China about 1873. This breed is kept almost exclusively by commercial duck farmers throughout the United States.

Other meat breeds are not so well adapted to commercial or general farming. The Aylesbury is not so hardy as the Pekin. The Muscovy ducks vary in size. They are not easily confined by ordinary fences. The Rouen matures slowly and has dark pinfeathers.

The Khaki-Campbell, developed in England, is a cross between the large meat breed Rouen and the egg breed, White Indian Runner. As its name indicates it has a khaki color. Egg production resembles that of the Runner, but the size is somewhat greater. The males may be marketed at 12 to 13 weeks at five pounds average weight. It has not yet been recognized as a standard breed by the American Standard of Perfection. However, recognition may be expected in the near future.

The egg class includes only one breed, the Runner (Fig. 14–3), commonly called the Indian Runner. It was probably developed in Belgium and Holland. There are three standard varieties of Runner ducks: the Fawn and White, the White, and the Penciled.

All the varieties have the same shape, but differ in plumage color. The breast is full, the body is long and narrow, sloping gradually into the neck and carried erect, with no indication of a keel, the body resembling somewhat that of a penguin in shape. The Runner duck is much smaller than breeds of the meat type, the adult drake having a standard weight of four and one-half



U. S. D. A.

Fig. 14–2. Large duck farm on Long Island.

pounds and the duck four pounds. They are among the best layers of all the American standard breeds of ducks and hold the same relative position in the duck family that the Leghorn does among the breeds of chickens. This breed lays a good-sized white egg, considerably larger than a chicken egg. Runner ducks are active, are good foragers, nonsitters, and hardy. Their skin is yellow and they make fair broilers, weighing from two and one-half to three pounds at about six weeks of age. They are not adapted for the production of large green ducks, but may be kept to produce ducklings of broiler size.

The ornamental class includes the Call, Crested White, and Black East India breeds of ducks.

The Call is small and may be considered the bantam of the duck family. The ornamental breeds are kept for exhibition and are used as decoys in wild duck shooting. The other ornamental breeds are also small.

Characteristics of ducks. Ducks have certain characteristics which class them as waterfowls and differentiate them from land fowls, such as the chicken and turkey (Fig. 14–6).

The duck is provided with short legs and webbed feet. These are assets in swimming. The bill is covered by a soft, sensitive membrane and edged with horny plates. Solid food material obtained from the water may be held and the water forced out through the plates. The feathers are concave toward the body and have a thick, soft covering on the under surface. They are well greased, and this helps to keep water from reaching the skin. The duck is further protected from the cold by having a thick layer of fat beneath the skin. This acts as a body insulator.

The duck does not have so large a percentage of edible muscle meat as the

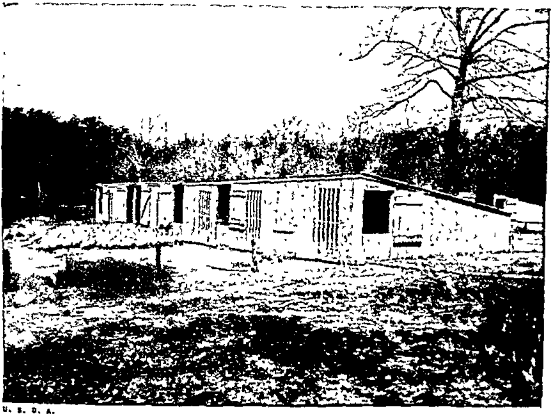
COURTESY "POULTRY TRIBUNE"

Fig. 14–3. Some breeds of ducks. Upper left, Pekin. Upper right, Rouen. Lower left, Runner. Lower right, Muscovy.

chicken (Table 9, Appendix). The meat is dark. The keel is flat and boatlike.

Duck breeding. Duck breeding for useful purposes in this country has been confined largely to breeding Pekin ducks for meat production.

Fig. 14–4. Hatching ducks. Top, a duck hatchery. (Courtesy Ridgeway Duck Farm.) Center, traying duck eggs. (U. S. D. A.) Bottom, a good hatch. (Courtesy Myers Poultry Farm.)



U. S. D. A.

Fig. 14–5. Flock of breeding ducks and breeding house.

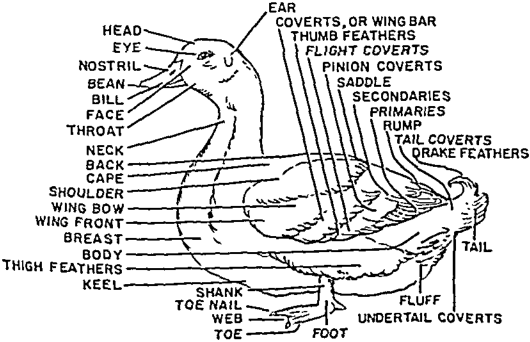


Fig. 14–6. Nomenclature of the male duck.

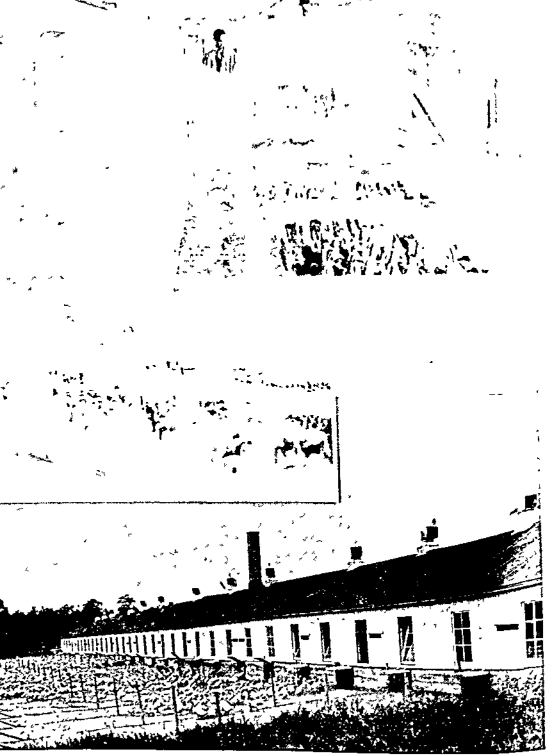


Fig. 14-7. Growing ducks. Top, brooding in a multiple-unit house. The brooder hovers are under the track and walk. Note the low pen partitions. (U. S. D. A.) Center, feeding ducks on range. Note the track and car for hauling feed. Bottom, outside runs in connection with a multiple-unit brooder house. (Courtesy C. M. Ferguson.)

Selection of breeders is usually made each year from the young ducks before the flock is marketed. The males can be identified by the middle tail feathers, which are curled up. Breeding ducks are selected for good length, width, and depth of body, and early maturity. Stock showing signs of coarseness are discarded. Heavy birds with very deep keels have a tendency to take on too much fat and are likely to show low egg production, poor fertility, and lack of vigor. Most ducks are kept only through their first laying season, as young ducks are better producers and lay earlier than older ones.

Mating of breeders is usually done in flocks (Fig. 14–5). One male is used for every six or seven females. Inbreeding is generally practiced. This may account for the poor hatchability that is often encountered.

Before much progress can be made in duck breeding, it will be necessary to trap-nest ducks; make pen matings; keep the breeders more than one year; and use the families of birds that have the best production, hatchability, and livability records.

Incubation of duck eggs. The incubation period for duck eggs from most of the breeds is twenty-eight days. Muscovy duck eggs require a thirty-three-to thirty-five-day incubation period.

Duck eggs are generally hatched in incubators and under the same conditions used for hatching chicken eggs (Fig. 14–4). More moisture is required at hatching time than is generally used for chicken eggs. Directions of the incubator manufacturer should be followed until experience has shown that improvements can be made.

Brooding ducks. Ducks are easier to brood than chicks or turkeys. They do not require so much heat or heat for so long a time. The ducks are removed from the incubator as soon as the hatch is completed. They are taken to the brooder house as soon as possible, placed under the brooder, and given feed and water.

About 100 to 150 ducks are placed in each pen and under each brooder. The temperature under the hover should be about 90° F. the first week, 85° F. the second week, 75° F. the third week, and about 65° F. the fourth and fifth weeks. When the birds are about six weeks old, they are transferred to the fattening shed where no artificial heat is used.

Straw or shavings make a very good litter for the brooder house. A guard should be placed around the brooder, one or two feet away from it, to keep the ducks from wandering away from the heat until they become accustomed to the brooder (Fig. 14–7).

The pen should be cleaned every week or ten days.

Housing ducks. The house should be located on well-drained soil. A chicken house is satisfactory for ducks. Shed-type houses are often used (Fig. 14–7). It is desirable to allow from four to six square feet of floor space for each breeding duck. Breeders are kept in flocks of from about 75 to 250.

Straw or shavings make satisfactory litter. The house should be cleaned as often as necessary to keep it clean and dry. Proper ventilation in the duck house, as in the chicken house, will help keep the place comfortable.

No perches are provided for ducks or other waterfowl because it is not their nature to roost. They rest on the floor.

Nests are generally provided which are made like stalls. They are about 12 inches wide, and 18 inches deep, and separated by boards about 12 inches high. The partition boards are nailed to a strip about 5 inches high, which forms the front of a row of nests placed against the back or side of the building. Some breeders provide no nests, but allow the birds to lay on the floor.

Troughs are generally used for water and mash boxes for feed.

Breeding ducks are generally provided with outside range (Fig. 14–5). When the range is limited or the farm large, the yards are limited to about one hundred feet in length and the width of the pen. If they extend into a stream, it will aid in keeping the place more sanitary. Fences about two feet high will hold ducks in their respective yards.

Feeding ducks. The quantitative nutritive requirements of ducks have not been carefully studied. Rations suitable for chickens (Chapter 8) appear to give satisfactory results when fed to ducks. The mash may be fed in the form of pellets, in dry ground form, or as a wet mash.

Starting rations generally contain 18 to 20 per cent protein (Table 14–1). They are generally fed the first two or three weeks.

Growing rations generally contain 16 to 18 per cent protein (Table 8–4). They are generally fed from three to six weeks.

Finishing rations generally contain about 16 per cent protein (Table 8–4). They are generally fed from about the sixth week until the ducks are marketed, which is around the tenth to twelfth week.

Growth rate and feed consumption are shown in Table 8–4. A 5-pound duck may be produced in seven to eight weeks.

Breeding duck rations are also believed to be about the same as those required for chickens (Table 14–1).

When the young ducks are selected for the breeding flock they are generally kept on a low protein bulky ration until about three or four weeks before hatching eggs are wanted. Free access to a growing mash and grains will suffice for this purpose. The mash may be limited to hold back egg production. The birds should be fed a breeding mash (Table 14–1) and grain, if the mash and system of feeding calls for it, about three or four weeks before hatching eggs are wanted and during the hatching season.

Breeding mashes may be fed in the form of pellets or as dry mash. Feeding all or a part of the mash in the form of pellets is preferred to feeding it as wet mash. In grain and mash feeding, it is often necessary to limit the grain in order to obtain adequate mash intake.

Oyster shells or limestone grit are kept before the layers at all times.

Lights may be used to stimulate egg production, as in the case of chickens.

Duck diseases. Ducks are not so susceptible to diseases as are chickens. Possibly this may be accounted for on the basis of selection. The breeders are picked out on the basis of vigor during the growing period. Another possible explanation is the fact that ducks have been accustomed to living in large numbers under rather unsanitary conditions. This unfavorable environment

Table 14–1

WATERFOWL MASH FEED FORMULAS *

Ingredients	Starter (1)	Grower (2)		Starter (1)	Grower (2)	
	0–2 weeks lbs.	Market (2) lbs.	Breeder (3) lbs.	0–3 weeks lbs.	Market (3) lbs.	Breeder (3) lbs.
Ground wheat	500	600	300	600	700	300
Wheat shorts	200	200	200	...	...	...
Wheat middlings	200	200	200	...	...	240
Ground yellow corn	300	300	300	400	400	200
Pulverized oats	.		220	220	230	400
Ground barley	340	340	...	200	200	100
Dehydrated green feed	60	60	200	60	60	200
Meat meal (50% protein)	40	50	40	40	40	40
Fish meal (65% protein)	50	30	80	50	20	80
Dried whey	40	40	60	40	40	50
Soybean meal (44% protein)	210	130	300	340	260	290
Ground limestone	20	20	50	20	20	50
Dicalcium phosphate	20	20	30	20	20	25
Iodized salt	10	10	20	10	10	20
Vitamin A supplement (10,000 I.U./gm.)	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin D_3 (15 I.C.U./gm.)	1.0	1.0	2.0	1.0	1.0	2.0
Manganese sulfate (feed grade)	0.25	0.25	0.5	0.25	0.25	0.25
Vitamin B_{12} (6 mg./lb.)	1.0	1.0	2.0	1.0	2.5	2.0
	grams	grams	grams	grams	grams	grams
Riboflavin	2	2	3	2	2	3
Niacin	20	20	20	20	20	20
Antibiotic	4–10	.		4–10	.	
Analysis						
Crude protein %	18	16.4	20.4	19.1	17.0	19.9
Productive energy calories/lb.	900	920	780	934	949	754

* Poultry Feed Formulas. Ontario Agricultural College. 1958
(1) All-mash
(2) Mash and grains fed free choice
(3) Mash fed with an equal amount of grains

through the years may have resulted in the establishment of a natural immunity against disease.

Some farmers who have been unable to produce chickens and chicken eggs profitably, because of disease, have changed to the production of ducks and

duck eggs. They are usually successful in raising the ducks, but often find themselves handicapped because of a lack of a good market.

One should not get the impression that ducks are entirely immune from disease. They are troubled by keel disease, pneumonia, and some other troubles.

Keel disease is indicated by lack of activity, loss of appetite, diarrhea, and heavy losses within a few hours. The trouble generally occurs in hot weather. It results from eating moldy or decayed feed or litter. To eliminate the trouble, renew the litter in the house, fill up the filthy puddles in the yards with sand, and feed fresh mash that is free from mold.

Pneumonia, colds, or bronchitis may be indicated by a sticky coat, watery eyes, wheezing, and sniffling sounds when breathing. This respiratory trouble results from overcrowding, poor ventilation, exposure, and overheating.

Marketing ducks. Since ducks are raised primarily for meat production, duck meat is the chief duck product marketed.

Ducks are generally marketed when 6 to 8 weeks old. The New York market prefers a duck that weighs about five and one-half pounds.

The ducks should not be held after the long tail feathers have reached their full length. If held longer, the birds go through a kind of molt, the gains are poor, and the quality of the meat is of lower value.

A V-shaped trap made of panels of fence, into which the ducks are driven, saves much handling of the ducks. The birds are handled by the neck. There is considerable loss in weight when ducks are marketed alive. Most of them are sent to market dressed.

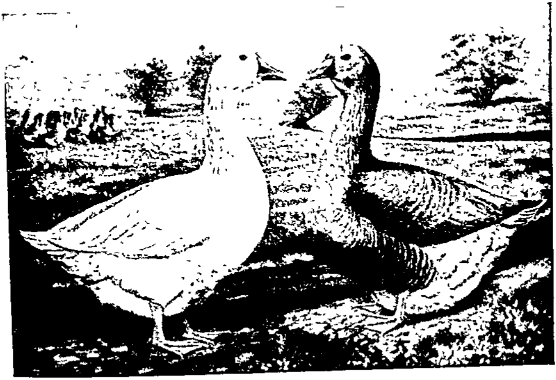
Ducks being dressed are hung up by the feet, the jugular vein severed in the throat below the base of the skull (Fig. 11–10 and 11), the bird scalded at about 140° F. for two to three minutes and the feathers removed on a picking machine similar to those used for picking chickens and turkeys (Fig. 11–13). Some processing plants remove most of the feathers as described, then dip the bird in hot defeathering wax at about 130° F., then into cold water, and finally remove the wax on a picking machine. The wax may be melted to strain out the feathers and used over again.

The ducks are cooled, eviscerated, and packed for market under conditions used for chickens (Chapter 11) The market classes of ducks are listed on p 383 Large cities provide the best markets.

Geese

Geese, like ducks, are raised primarily for meat production. They are hardy and easy and cheap to raise on general farms, since they will get almost all the feed they need from a good pasture. Geese are raised in all sections of the United States, but most of them are produced in the North Central states. Geese make up only about 5 per cent of the poultry raised in the United States.

Breeds of geese. Breeds of geese in the United States are descended from the wild gray goose and have been domesticated for many centuries. Six



COURTESY "POULTRY TRIBUNE"

Fig. 14–8. Breeds of geese. Left, Emden; right, Toulouse.

breeds are recognized as standard in this country, namely, Toulouse, Emden, African, Chinese, Canada, and Egyptian. The breeds found on most farms are crossed or mixed breeds and several pounds lighter than the standard breeds.

The Toulouse (Fig. 14–8) is the largest and most popular breed of geese. The adult gander weighs twenty-six pounds and the adult goose twenty pounds. This breed has a broad, deep body, and is loose feathered. The color of the plumage is dark gray on the back, gradually shading to light gray edged with white on the breast, and to white on the abdomen. The Toulouse will lay from fifteen to thirty-five eggs a year.

The Emden is a pure white, closely feathered breed of geese (Fig. 14–8). The adult gander weighs twenty pounds and the goose eighteen pounds. The Emden does not lay quite so many eggs as the Toulouse, but is a better sitter.

The other breeds of geese are of much less economic importance.

Breeding and management of geese. Geese are generally raised in small numbers on general farms. They are very hardy and not subject to many diseases. They thrive well on pasture. Geese need a shed or some other means of protection from the snow and cold, and shade for protection from the hot sun.

Geese, like other kinds of poultry, should be selected for size, production, and vigor. Medium-sized birds are the most desirable. They should be mated several months before the breeding season. Birds should be mated in the fall when hatching eggs are wanted in the spring. Geese matings are not changed from year to year unless the birds will not mate.

It is difficult to determine sex in geese, especially the young stock. The gander is usually somewhat larger and coarser than the goose and has a shrill,

high voice, while the female has a harsh, coarse cry. The gander has a longer neck and a larger head.

Geese of all ages may be readily sexed by physical examination of the vent. Place the goose on its back and press the vent wall between the two fingers. The hard genital eminence may be felt to protrude.

A gander may be mated with from one to four geese, but pair or trio matings usually give the best results. A young gander is usually mated with only one or two geese. Flock or pen matings may be used. Four to twenty-five geese may be ranged on an acre of ground. Fences two or three feet high will keep geese confined to a given range.

Toulouse and Emden geese breed and produce some stock in the second year, but do not mature or give best results before the third year. Females may be kept until eight to ten years old and ganders until six or seven years old.

Geese are allowed to make nests on the floor of the house or in large boxes or barrels, or shelters scattered on the range for that purpose. Goose eggs should be gathered daily, kept in a cool place, and hatched under a hen, goose, or in an incubator. From three to seven eggs may be set under a hen, or ten to fifteen under a goose. Eggs set under a hen should be turned by hand as they are too large for the hen to turn. The period of incubation of goose eggs varies from twenty-eight days in the small breeds to thirty-four or thirty-five days in the large breeds.

Goslings may be brooded with a hen, a goose, or with an artificial brooder. If brooded in the spring, when pasture is good, they will need only heat for a week or so. Goslings should be kept dry and out of water until they are two to four weeks old.

Artificial incubation. Studies made at Ohio State University indicate that the following practices will result in good hatchability.

1. Turn eggs completely over at least once daily and preferably four times.
2. Incubate the eggs at 99 to 99.5° F. in a forced-draft incubator.
3. Maintain a high humidity, especially during the hatch. A wet bulb reading of 94° F. should be maintained during the hatch.
4. Dip the eggs in lukewarm water for about a minute twice weekly.

Feeding geese. Geese are generally raised where they have a good grass range or pasture, and, except during the winter months, usually pick up most of their living. The pasture may be supplemented with light feeds of home-grown grains, depending upon the condition of the pasture. Geese rations are listed in Table 14–1.

Breeding stock should be fed grain and roughage during the winter, when pasture is not available. Oats make a desirable grain feed. A limited amount of corn, wheat, or barley may be used. Silage may also be used. In the early spring, the geese should be fed a mash feed in addition to the roughage and grains, in order to stimulate egg production. Any satisfactory chicken laying mash may be fed. Oyster shells or limestone grit should be kept available for eggshell formation

Goslings may be fed a mash when raised in confinement. When raised on green grass range, they may be fed a mixture of grains mixed with liquid

skim milk or buttermilk to make a crumbly mash. When goslings are raised in small numbers on good pasture, they will need little or no grain or mash feed after they are about three or four weeks old. Whole grains should not be fed until the goslings are well-feathered.

Finishing geese for market involves fattening them. They may be range or pen fattened for about a month before going to market. The birds are given all the corn they will clean up in addition to the mash. The pens should be kept partly darkened and the birds disturbed as little as possible. An increase in weight of from four to six pounds can be obtained by this method of feeding.

Marketing geese. There is some demand for young geese from June to January, but most of them are sold at Thanksgiving and Christmas. Ten-weeks-old goslings may weigh as much as ten to twelve pounds and are marketed as green geese. If not sold at this age, they should not be sold until about five months old. Large cities containing a considerable foreign population are usually the best markets for geese.

Geese are usually killed and picked in the same manner as other kinds of poultry, but are much more difficult to pick than chickens. Care should be taken in handling geese at market time as the flesh bruises easily. After killing and bleeding, the feathers are generally removed following scalding. After geese have been picked, they are generally washed and put in ice water to cool.

Feathers have been plucked from live geese for centuries. They are usually picked in the spring or fall, or both times. The feathers are removed only when the quills are dry and do not contain blood. Just before the molt is a good time to pluck the feathers. About a pound of feathers may be obtained from a goose during a year. The demand for goose feathers has been declining in recent years.

Goose livers are mixed with pork, flour, butter, and spices and sold under the name of "Patty" and other trade names.

Weeder geese is a term applied to goslings and geese used primarily for weeding a wide variety of crops and plants. Weeding with goslings is not new, however, greater use in recent years has promoted large scale hatchery production for goslings. Geese are selective in consuming grass which they prefer over many broadleaf plants. Young goslings that are five to six weeks of age are preferred to mature geese for weeding purposes.

Pigeons

Pigeons are kept in all parts of the United States for squab production, messengers, and exhibition (Fig. 14–9).

There is a demand for squabs, especially in large cities, to take the place of game. The chief difficulties in squab production are in finding suitable markets for the small amount of squab meat produced by individuals and in finding suitable stock for producing big squabs.

Breeding pigeons. There are many breeds of pigeons, but only a few of


U. S. D. A.

Fig. 14-9. A pigeon house.

economic value for squab production. The Homer is probably the most popular breed of pigeons. It is prolific, hardy, active, and quiet in temperament.

It is difficult to determine by casual observation the age and sex of pigeons, and this makes it difficult for the buyer to determine the value of the stock. The medium-sized breeds of pigeons which do not raise at least six pairs of squabs annually to market age should be either culled or remated. Good pigeons for breeders have a white or pinkish-white skin and light-colored legs. Pigeons are most valuable as squab producers when two to five years old.

Pigeons mate in pairs and usually remain with their mates throughout life, although the mating may be changed if desired. To bring about the mating desired, place the male and female in a coop and leave them there for six to fourteen days, or until they become settled.

The pigeon hen lays an egg, generally skips a day, and then lays again. The male generally sits on the eggs during the middle of the day, and the female the remainder of the time. The incubation period for pigeon eggs is about seventeen days.

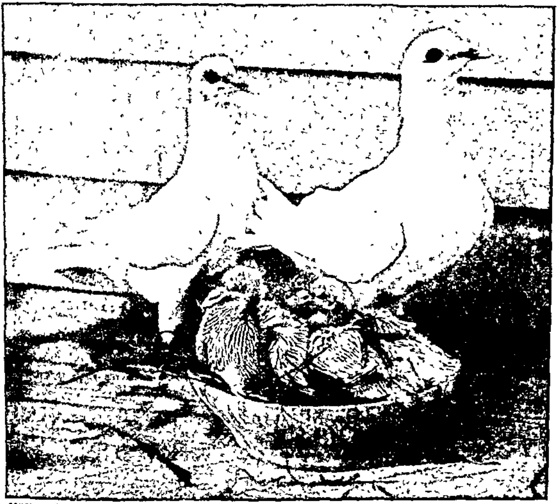
Feeding and management of pigeons. Squabs are reared and fed by both of the parent birds on a thick, creamy mixture called pigeon milk, produced in the crops of the pigeons. Pigeons usually feed their squabs shortly after they themselves are fed.

Pigeons are not fed any mash or green feed. They are fed a ration of whole grains and supplied with water and grit. A grain mixture advocated by the U. S. Department of Agriculture (Farmers' Bul. 684) is as follows:

Whole yellow corn	30 lbs.
Kafir or milo	25 lbs.
Cowpeas or field peas	20 lbs.
Hard red wheat	20 lbs.
Vetch or hemp seed	5 lbs.

The grain should be fed twice daily, the birds being given all they will eat. Pigeons should not be disturbed more than is absolutely necessary.

Pigeons may be raised in any available building when kept in small



COURTESY C. S. PLATT, RUTGERS UNIVERSITY

Fig. 14–10. A pair of White King breeders entered in the New Jersey pigeon-breeding contest, with a pair of squabs. The record of this pair was 19 squabs in a year, weighing 383 ounces.

groups. The quarters should be dry, well ventilated, and provided with plenty of daylight. Pigeons are allowed two and one-half to three and one-half square feet of floor space per bird. Not more than forty pairs should be kept in a single pen.

Nearly all pigeons kept for squab production are confined by the use of an outside fly or yard covered with wire which is built on the south side of the house (Fig. 14–9).

The interior fittings should consist of a double nest for each pair of breeders, nest, bowls, and feed hoppers. Nest compartments should be 12 inches high, 16 inches deep, and 24 inches wide, divided into two parts. A box of straw may be kept in the pen so that the pigeons may build their own nests. The feed hoppers and drinking vessels should be covered with wire in such a way that the birds cannot get in them. Shallow bath pans should be kept in the yards and the birds allowed to use them, except in cold weather.

Marketing squabs. The production of squabs from each pair of breeders varies from one or two to as high as ten or eleven pairs a year. Homer squabs

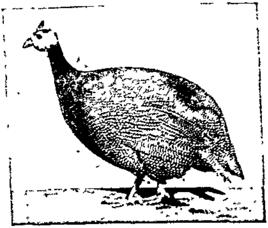

U. S. D. A.

Fig. 14–11. A Pearl guinea fowl.

generally weigh eight to eleven pounds per dozen. They gain two-thirds of their mature weight in four weeks. Squabs are fed by their parents until markered. They are sold when three or four weeks old, before they can leave their nests. Squabs are in good condition when fully feathered under the wings.

Squabs are killed and dressed much like other poultry.

Guineas

The guinea fowl is often used as a substitute for game birds, such as grouse, partridge, quail, and pheasant.

Most of the guineas are raised in small numbers on general farms of the Middle West and southern states.

Guineas might be more popular were it not for their harsh and seemingly never-ending cry, and their bad disposition.

Guineas are found in the wild state in Africa. They have been domesticated and scattered throughout the world. Of the three domesticated varieties, the Pearl is by far the most popular. It has a purplish-gray plumage, dotted or "pearled" with white (Fig. 14–11).

Like quail and most other wild birds, guinea fowls have a tendency to mate *in pairs*. However, *one male may be mated with three or four hens*. If given the freedom of the farm, the birds generally hide their nests. They may lay twenty or thirty eggs in the spring of the year before going broody. The incubation period for guinea eggs is twenty-eight days. They may be hatched in incubators and brooded under brooders, using the same procedures as used for chickens.

Guineas are fed in much the same manner as chickens. If given a chance, they forage well and can be depended upon to secure much of their food from weed seeds, grass, insects, and worms, when kept in small numbers.

The marketing season for guinea fowl is during the late summer and fall. The demand is for young birds weighing from one and one-half to two pounds each. They are killed and dressed in much the same manner as chickens.

Pheasants

Pheasants are generally classed with game birds. However, they are closely related to the chicken structurally and may be produced in a similar manner. A brief discussion of the pheasant business will therefore be included here.

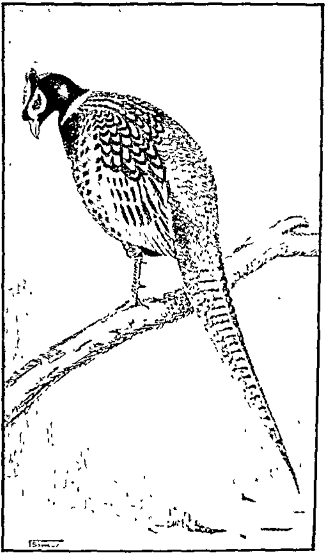
Pheasants are generally raised for stocking farms reserved for hunting by

sportsmen. The ring-neck pheasant imported from China is the most popular of several varieties.

Pheasants may be propagated much like chickens. However they need to be placed on the ground, fed whole grains, and given a chance to become acclimated to natural plant and shrubbery protection before being turned loose, usually at eight to ten weeks of age.

Pheasants reproduce well under natural conditions if protected on a game preserve and supplied with some supplemental whole grains.

Pheasants lay eggs in the spring and early summer. The incubation period is 23 to 24 days. Pheasants may be started in a battery or on the floor with a hover. Brooding practices for pheasants are much the same as for chickens.



COURTESY FISH AND WILDLIFE SERVICE U. S. DEPARTMENT OF THE INTERIOR

Fig. 14–12. Ring-neck pheasant. (Drawing by Sim.)

Peafowls

Peafowls once had some importance as food for man, but now they are kept almost entirely for ornament (Fig. 14–13).

The native home of the peafowl is in India. The birds like range and shrubbery or trees for a home. When confined to yards with sheds for shelters, they should be some distance from the house because the birds are noisy, especially at night.

Four or five hens may be mated with one cock bird. The birds start to lay the second year and may lay five to nine eggs per year. The eggs may be incubated artificially or under hens. The incubation period is twenty-eight to thirty days. The young birds may be brooded artificially or with hens.

Peafowls are generally fed a ration consisting largely of grains and green feeds. When given freedom of a range, the birds will secure most of their food from weed seeds, grass, insects, worms, etc.

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Fig. 14-13. The peafowl.

Swans

Swans are kept largely for ornamental purposes and probably should not be classed as poultry. They are more common in European countries than in the United States.

Swans are very hardy and need no protection except in extremely cold weather. They live in pairs and remain faithful to each other until death. Swans make nests of sticks and rubbish and lay from six to eight large greenish-white eggs each year. The incubation period of swan eggs is about six weeks.

Swans live on water plants, soft roots, and insects, under natural conditions. They may be fed the same kind of food fed to other poultry. It should be supplemented with green succulent feed.

Swans live to be very old. The females will breed for thirty years, and the males have been known to live for more than sixty years.

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Appendix

Agricultural Colleges and Experiment Stations in the United States and Canada

Agricultural colleges and experiment stations offer publications covering many agricultural subjects, including poultry. A list of the available bulletins, circulars, leaflets, etc., and information regarding them may be obtained from the institutions. Except where otherwise noted, the state experiment stations *in the United States are at the colleges of agriculture.*

UNITED STATES

Alabama	Auburn
Alaska	College
Arizona	Tucson
Arkansas	Fayetteville
California	Berkeley
Colorado	Fort Collins
Connecticut	
College and station	Storrs
Station	New Haven
Delaware	Newark
Florida	Gainesville
Georgia	Athens
Hawaii	Honolulu
Idaho	Moscow
Illinois	Urbana
Indiana	Lafayette
Iowa	Ames
Kansas	Manhattan
Kentucky	Lexington
Louisiana	Baton Rouge
Maine	Orono
Maryland	College Park
Massachusetts	Amherst
Michigan	East Lansing
Minnesota	St Paul
Mississippi	State College
Missouri	Columbia
Montana	Bozeman
Nebraska	Lincoln
Nevada	Reno
New Hampshire	Durham
New Jersey	New Brunswick
New Mexico	State College
New York	
College and station	Ithaca
Station	Geneva
North Carolina	Raleigh
North Dakota	Fargo
Ohio	
College and Station	Columbus
Station	Wooster
Oklahoma	Stillwater
Oregon	Corvallis
Pennsylvania	State College
Puerto Rico	Rio Piedras
Rhode Island	Kingston
South Carolina	Clemson
South Dakota	Brookings
Tennessee	Knoxville
Texas	College Station
Utah	Logan
Vermont	Burlington
Virginia	Blacksburg
Washington	
College and station	Pullman
Station	Puyallup
West Virginia	Morgantown
Wisconsin	Madison
Wyoming	Laramie
United States Department of Agriculture	Washington, D. C.

CANADA

Alberta	Edmonton	Quebec	Macdonald College
British Columbia	Vancouver	Dominion Department of Agriculture	Ottawa
Manitoba	Winnipeg		
Nova Scotia	Truro		
Ontario	Guelph		
Saskatchewan	Saskatoon		

ABSTRACT JOURNALS

Hundreds of scientific publications which contain agricultural information, including poultry, are published annually. The data from the bulletins and articles are summarized in brief abstracts and published in special abstract journals. Some of these are as follows:

Biological Abstracts. Philadelphia, Pa.
Chemical Abstracts. Columbus, O.
International Review of Poultry Science. Rotterdam, Holland.
Poultry Digest. Hanover, Pa.
World's Poultry Science Journal, Columbus, O.

POULTRY INDUSTRY DIRECTORIES

Annual Directory. Better Farming Methods. Watt Publishing Co., Mount Morris, Ill.
Annual Directory. County Agent and Vo-Ag Teacher. Ware Bros. Co., 317 N. Broad St., Philadelphia 7, Pa.
Annual Products Directory. Hatchery and Feed. Watt Publishing Co., Mount Morris, Ill.
Annual Directory Issue. Turkey World. Watt Publishing Co., Mount Morris, Ill.
Blue Book of the Poultry Industry. Lynnes Publishing Co., Elmhurst, Ill.
Who's Who in the Egg and Poultry Industries. Urner-Barry Co., 92 Warren St., New York 7, N. Y.

PERIODICALS

Many publications regularly or frequently contain articles on poultry products. Some of these are:

Agricultural Marketing. U. S. D. A., A. M. S.
Agricultural Research. U. S. D. A., A. R. S.
American Egg and Poultry Review
American Hatchery News
American Journal of Veterinary Research
American Veterinary Medical Association Journal
Avian Diseases
Biochemical Journal
Broiler Producer
Broiler Growing
Broiler World

Canadian Journal of Agriculture
Canadian Poultry Review
Cornell Veterinarian
Egg Producer
Eggsaminer
Endocrinology
Everybodys Poultry Magazine
Farm Journal
Federation Proceedings. Fed. Am. Soc. Exp. Biol.
Feed Age
Feed Situation. U. S. D. A., A. M. S.
Feedstuffs
Food Engineering
Food Processing
Food Research
Food Technology
Foreign Agriculture. U. S. D. A.
Genetics
Hatchery and Feed
Journal of Farm Economics
Journal of Nutrition
Magazine of Ducks and Geese
Modern Packaging
Modern Poultry Keeping
National Food Situation. U. S. D. A., A. M. S.
Nulaid News
Nutrition Abstracts and Reviews
Nutrition Reviews
Pacific Poultryman
Poultry and Egg Situation. U. S. D. A., A. M. S.
Poultry and Eggs Weekly
Poultry Digest
Poultry Processing and Marketing
Poultry Science
Poultry Supply World
Poultry Tribune
Quick Frozen Foods
Successful Farming
Turkegram
Turkey World
World's Poultry Science Journal

SUGGESTED PROCEDURE FOR REVIEWING THE LITERATURE ON POULTRY SUBJECTS

I. SOURCES OF INFORMATION—REFERENCES AND ABSTRACTS

A. GENERAL AGRICULTURE

1. *Bibliographic Index:* A cumulative bibliography of bibliographies. Semiannual with annual and four year accumulations. Lists alphabetically

by subject separately published bibliographies and bibliographies issued in monographs and journals. Includes agricultural and scientific bibliographies in about 1500 periodicals including many in foreign languages.

2. *Biological Abstracts:* A comprehensive abstracting and indexing journal of the world's literature in theoretical and applied biology, exclusive of clinical medicine. Twelve issues per year plus annual author and subject indexes. An indispensable reference work for all workers in biological sciences.

3. *Agricultural Index:* A cumulative subject index to agricultural periodicals, books and bulletins. Issued monthly except in September. Alphabetical subject index to more than a hundred periodicals and to bulletins, books and publications of agricultural departments, experiment stations, extension services, agricultural societies and other agencies.

4. *Bibliography of Agriculture:* U. S. Dept. of Agriculture Library. Issued monthly. Check lists of U. S. Dept. of Agriculture publications, state agricultural experiment station publications and state agricultural extension publications are provided. Classified by subject, indexed monthly by author and annually by author and subject. The most comprehensive single index to agricultural literature.

B. POULTRY SCIENCE

The field lacks a comprehensive indexing or abstracting journal. The principal abstracting journals containing poultry subjects in addition to those previously reported under general agriculture are:

5. *Animal Breeding Abstracts:* Poultry and egg production, growth, genetics, physiology of the egg, reproduction and sex. Issued quarterly at Edinburgh, Scotland.

6. *Nutrition Abstracts and Reviews:* Feeding and nutrition of poultry and chemical composition of poultry products. Issued quarterly at Aberdeen, Scotland.

7. *Food Science Abstracts:* Processing and composition of poultry products as food. Issued quarterly. London, England.

8. *Chemical Abstracts:* Chemical composition and analysis of poultry products and poultry feeding stuffs.

C. VETERINARY MEDICINE

Biological Abstracts, Bibliography of Agriculture, Chemical Abstracts and Bibliography of Agriculture, previously described, and:

9. Quarterly Cumulative Index Medicus.
10. Current List of Medical Literature.

D. FOOD AND NUTRITION

Bibliography of Agriculture, Chemical Abstracts, Biological Abstracts, Nutrition Abstracts and Reviews and Food Science Abstracts.

E. SOCIAL SCIENCES (ECONOMICS AND STATISTICS)

Agricultural Index and Bibliography of Agriculture, previously listed, and:

11. Agricultural Statistics. Issued annually by the U. S. Department of Agriculture.

12. Statistical Abstract of the United States. Issued annually by the U. S. Department of Commerce.

II. PROCEDURE

1. Find out what has already been done before starting work on a problem.
2. Look in the abstract journals or bibliographies for references.
3. Look in the current issues of journals, and as far back as one to two years for the most recent references. Abstracts of articles are slow in appearing in abstract journals.
4. Check the references at end of the articles against those found in the abstract journals or vice versa to be sure that none has been missed.
5. Record each reference on a separate card or page. This will facilitate the checking for duplications and make it possible to group references in separate sub-headings.
6. Record the references according to the style used in Poultry Science unless otherwise specified. Complete listing at the time will avoid the necessity of looking up the reference again when writing a report, thesis or manuscript for a journal article.
7. Abstract the articles on the abstract cards or pages and read those carefully that are of special importance.

POULTRY PERFORMANCE TESTS IN THE UNITED STATES *

EGG PRODUCTION

California Official Random Sample Egg Laying Contest. Modesto
Storrs Egg Laying Test. University of Connecticut, Storrs
Florida National Egg Laying Test and Florida Random Sample Test. Chipley
Iowa Multiple Unit Poultry Test. 409½ Douglas Ave., Ames
Minnesota Random Sample Test. Stillwater
Missouri National Egg Laying Test and Missouri Official Random Sample Poultry Test. Mountain Grove
New Hampshire Multiple Unit Egg Production Test. University of New Hampshire, Durham
New Jersey Random Sample Egg Laying Test. Rutgers University, New Brunswick
Central New York Official Random Sample Poultry Test. Cornell University, Ithaca
Western New York Official Random Sample Test. Cornell University, Ithaca
New York Egg Laying Test. Farmingdale, Long Island
North Carolina Poultry Random Sample Test. North Carolina State College, Raleigh
Pennsylvania Random Sample Laying Test #2. Harrisburg

* Hatchery and Feed 33 (2) 86–88, 1959

Rhode Island Egg Laying Test. University of Rhode Island, Kingston
Tennessee Random Sample Laying Test. University of Tennessee, Knoxville
Texas Random Sample Egg Production Test. Texas A & M College, College Station
Intermountain Random Sample Egg Laying Test. Utah State University, Logan
Wisconsin Chicken Random Sample Test. Oregon

BROILER PRODUCTION

Arkansas Meat Performance Broiler Test. Fayetteville
California Official Random Sample Chicken Meat Production Test. Modesto
Georgia Broiler-Breeding and Testing Project. University of Georgia, Athens
Maine Production and Broiler Test. Augusta
Massachusetts Chicken Broiler Test. University of Massachusetts, Amherst
Michigan Broiler Test. Michigan State University, East Lansing
Montana Broiler Test. Montana State College, Bozeman
New Hampshire Broiler Test. University of New Hampshire, Durham
Tennessee Random Sample Broiler Test. University of Tennessee, Knoxville
Texas Random Sample Meat Production Test. Texas A & M College, College Station

TURKEY PRODUCTION

California Random Sample Turkey Meat Production Test, #3, Modesto
Kansas Central Random Sample Turkey Meat Production Test, Kansas State College, Manhattan
Massachusetts Turkey Test, University of Massachusetts, Amherst
Minnesota Central Random Sample Turkey Meat Production Test, 611 State Office Building, St. Paul 1.
Central Turkey Meat Production Tests of Nebraska, University of Nebraska, Lincoln
North Dakota Central Random Sample Turkey Test, Bismarck
Central Turkey Meat Production Test of Pennsylvania, Department of Agriculture, Harrisburg
Texas Central Random Sample Turkey Meat Production Test, Texas A & M College, College Station

CHART FOR DETERMINING IMPORTANT CHARACTERISTICS OF STANDARD VARIETIES IN THE AMERICAN, ASIATIC, ENGLISH AND MEDITERRANEAN CLASSES

Class / Characters	Comb	Breed	Variety	Standard Weight Ck	Standard Weight Ckl	Standard Weight Hen	Standard Weight Pullet
American Class							
Varieties in this class have yellow skin, non-feathered shanks, red earlobes and all except the Lamonas lay brown-shelled eggs.	Single	Plymouth Rocks	Barred, White, Buff, Silver-Penciled, Partridge, Columbian and Blue	9½	8	7½	6
		Javas	Mottled and Black	9½	8	7½	6½
		Jersey Giants	Black	13	11	10	8
		Rhode Island Reds	Single-Comb	8½	7½	6½	5½
		New Hampshires	*Sorrel	8½	7½	6½	5½
		Lamonas	*White	8	7	6½	5½
	Rose	Wyandottes	Silver-Laced, Golden-Laced, White, Black, Buff, Partridge, Silver-Penciled and Columbian	8½	7½	6½	5½
		Dominiques	*Barred	7	6	5	4
		Rhode Island Reds	Rose-Comb	8½	7½	6½	5½
		Rhode Island Whites	*Rose-Comb	8½	7½	6½	5½
	Cushion	Chanteclers	White Partridge	10	8½	7½	6½
Asiatic Class							
Varieties in this class have feathered shanks, red earlobes, lay brown-shelled eggs. The Langshans have white skin and the other breeds have yellow skin.	Pea	Brahmas	Light	12	10	9½	8
			Dark and Buff	11	9	8½	7
	Single	Cochins	Buff, Partridge, White, and Black	11	9	8½	7
		Langshans	Black, and White	9½	8	7½	6½

English Class							
Varieties in this class have non-feathered shanks, red earlobes. All except the Dorkings and Redcaps lay brown-shelled eggs. The Cornish have yellow skin but the other breeds have white skin.	Single	Dorkings	White	7½	6½	6	5
			Silver-Gray and Colored	9	8	7	6
		Orpingtons	Buff, Black, White, and Blue	10	8½	8	7
		Sussex	Speckled, Red, and Light	9	7½	7	6
		Australorps	*Black	8½	7½	6½	5½
	Rose	Redcaps		7½	6	6	5
	Pea	Cornish	Dark, White, White-Laced Red and Buff	10½	8½	8	6½
Mediterranean Class							
Varieties in this class have non-feathered shanks and white earlobes. They are noted for their white-shelled eggs. The Leghorns and Anconas have yellow skin but the other breeds have white skin.	Single	Leghorns	Dark Brown, Light Brown, White, Buff, Black, Silver, Red, Black Tailed, Red and Columbian	6	5	4½	4
		Minorcas	Black	9	7½	7½	6½
			White and Buff	8	6½	6½	5½
		Spanish	White-Faced Black	8	6½	6½	5½
		Blue Andalusian		7	6	5½	4½
		Anconas	Single-Comb	6	5	4½	4
	Rose	Leghorns	Dark Brown, Light Brown, and White	6	5	4½	4
		Minorcas	Black and White	8	6½	6½	5½
		Anconas	Rose-Comb	6	5	4½	4
	Buttercup	Buttercups		6½	5½	5	4

* Non-standard variety names.

Table A-1

AVERAGE COMPOSITION OF FEEDS [1]

Feeding Stuff	Moisture Per cent	Protein Per cent	Fat Per cent	Fiber Per cent	N-free extract Per cent	Ash Per cent	Calcium Per cent	Phosphorus Per cent	Manganese mg./lb.	Carotene mg./lb.	Niacin mg./lb	Riboflavin mg./lb.	Pantothenic acid mg./lb.
Alfalfa meal dehydrated, 17% protein	6.7	17.8	2.8	24.2	39.7	8.8	1.7	0.2	15.0	36.0[2]	8.7	7.3	12.3
Alfalfa meal, sun-cured, 17% protein	7.8	17.6	2.0	23.8	38.9	9.9	1.4	0.2	...	24.0[2]	16.1	5.0	12.7
Alfalfa meal, dehydrated, 20% protein	7.1	20.9	2.9	19.8	38.2	11.1	1.7	0.3	28.6	60.0[2]	17.3	7.4	18.5
Alfalfa meal, sun-cured, 20% protein	8.1	20.3	3.2	17.8	40.3	10.3	1.4	0.2	...	48.0[2]	22.7	7.2	13.6
Barley, excluding Pacific Coast	10.6	12.7	1.9	5.4	66.6	2.8	0.09	0.5	8.3	...	24.1	0.8	3.7
Barley, Pacific Coast	11.0	9.7	2.2	6.2	68.7	2.2	0.06	0.4	7.8	1.8	20.0	0.6	3.3
Bone meal, raw	6.4	26.0	5.0	1.0	2.5	59.1	21.7	10.0	1.9	...	1.9	0.5	1.0
Bone meal, steamed, special	3.3	13.4	9.7	1.1	1.2	71.3	29.3	15.1	5.1	...	2.0	0.4	0.8
Buttermilk, dried	7.6	32.4	6.4	0.3	43.3	10.0	1.4	0.9	1.5	...	2.8	15.8	13.5
Corn, dent, yellow	15.0	8.9	3.9	2.0	68.9	1.3	0.02	0.3	2.3	1.33	9.8	0.5	2.6
Corn gluten meal, 41% protein	8.6	42.9	2.0	3.9	40.1	2.5	0.2	0.4	4.4	10.0	24.8	0.7	3.8
Cottonseed oil meal, 41% protein	7.8	41.2	6.2	11.2	27.7	5.9	0.2	1.2	12.9	...	13.0	2.5	4.4
Crab meal	7.9	31.5	2.2	10.5	6.0	41.9	14.5	1.5	...	...	...	2.3	3.0
Distillers dried corn grains, with solubles	6.9	28.8	8.9	9.0	41.7	4.7	0.2	0.7	18.2	...	36.3	3.4	5.2
Distillers dried solubles	6.9	28.0	6.7	3.3	47.6	7.5	0.4	1.4	45.4	...	54.3	5.2	8.9
Fish meal, menhaden	6.4	62.2	8.5	0.7	4.2	18.0	5.0	3.4	10.0	...	25.9	2.4	...

[1] The data on the average composition of feeds were supplied by the Committee on Feed Composition of the National Research Council. They are a combination of data compiled by the Committee on Feed Composition and by F. B. Morrison (Feeds and Feeding, 21st Edition), who is a member of this Committee.

[2] Rough approximations since carotene content is too variable for dependable averages.

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AVERAGE COMPOSITION OF FEEDS (cont'd)

Feeding Stuff	Moisture Per cent	Protein Per cent	Fat Per cent	Fiber Per cent	N-free extract Per cent	Ash Per cent	Calcium Per cent	Phosphorus Per cent	Manganese mg./lb.	Carotene mg./lb.	Niacin mg./lb.	Riboflavin mg./lb.	Pantothenic acid mg./lb.
Fish meal, sardine	6.9	67.2	5.0	0.6	5.4	14.9	4.2	2.5	10.3	..	26.0	2.5	1.3
Fish meal, whitefish	9.6	63.0	6.7	0.1	0.1	20.5	6.8	3.7	5.0	...	36.0	4.0	1.4
Hominy feed, white, 5% fat	10.1	10.8	5.7	4.7	66.0	2.7	0.05	1.0	8.2	..	25.1	1.0	3.1
Hominy feed, yellow	9.5	11.1	7.1	5.8	63.9	2.6	0.05	0.7	6.9	0.5	22.6	1.0	3.5
Limestone			...	..	..		38.3		...	...	...	...	...
Linseed oil meal, o.p., 33% protein	8.8	35.0	5.6	8.1	36.9	5.6	0.4	0.9	19.1	...	18.9	1.9	7.5
Linseed oil meal, o.p., 37% protein	9.1	38.0	5.9	7.7	33.7	5.6	0.5	0.9	18.6	..	14.7	1.7	8.9
Meat scrap, 52% protein	6.9	52.9	7.3	2.2	4.3	26.4	8.7	4.4	4.0	...	27.1	2.4	2.1
Meat scrap, 60% protein	6.2	60.9	8.8	2.4	1.1	20.6	6.3	3.5	5.4	..	23.7	2.5	2.3
Meat and bone scrap, 50% protein	6.4	50.6	10.0	2.0	2.0	29.0	9.7	4.2	5.3	...	21.4	2.1	1.5
Milk, skimmed, dried	5.8	34.7	1.2	0.2	50.3	7.8	1.3	1.1	1.2	...	5.7	10.0	16.0
Molasses, beet	19.5	8.4	0.0	0.0	62.0	10.1	0.08	0.02	.	.	22.0	...	...
Molasses, cane	26.0	2.9	0.0	0.0	62.1	9.0	0.7	0.08	.	...	20.9	1.1	17.9
Oats, excluding Pacific Coast	9.8	12.0	4.6	11.0	58.6	4.0	0.09	0.4	19.2	...	8.2	0.4	6.8
Oats, Pacific Coast	9.8	9.0	5.4	11.0	61.1	3.7	.			...	...	...	...
Oatmeal, feeding	9.3	15.0	7.4	2.0	64.4	1.9	0.07	0.4	13.6	...	4.5	0.6	6.6
Oyster shell, ground				..	..	...	37.9	..	...	...	...	...	...
Peanut oil meal, o.p., 43% protein	7.2	43.1	7.6	13.9	23.0	5.2	0.1	0.6	..	...	77.5	2.4	24.1
Phosphate, defluorinated rock	.	.		...	.	.	28.3	12.3	40.9	...	...	...	...
Phosphate, dicalcium	.			.			26.5	20.5	...	...	...	...	...
Rice bran	9.0	12.8	13.1	12.7	41.7	10.7	0.08	1.4	70.9	...	129.1	1.4	10.3

AVERAGE COMPOSITION OF FEEDS (cont'd)

Feeding Stuff	Moisture Per cent	Protein Per cent	Fat Per cent	Fiber Per cent	N-free extract Per cent	Ash Per cent	Calcium Per cent	Phosphorus Per cent	Manganese mg /lb.	Carotene mg /lb.	Niacin mg /lb.	Riboflavin mg /lb	Pantothenic acid mg /lb.
Rice polishings	9 7	12.7	11.4	3.5	56.6	6.2	0 04	1.1	..	...	325.0	0.9	5.5
Rye grain	10 5	12 6	1.7	2.4	70.9	1.9	0 01	0.3	37.0	...	7.1	0.7	4.2
Sorghum, kafir	10.5	11.2	2.9	2.3	71.1	2 0	0. 4	0.3	7.5	...	18.3	0.5	5.7
Sorghum, milo	10 6	11.3	2.9	2.2	71.3	1.7	0 03	0 3	5.9	...	13.1	0.4	5.0
Sorghum, milo head chop	10.0	10.1	2.5	6 8	67.1	3.5	0.1	0.3	...	...	...	0.9	...
Soybean oil meal, 41% protein	10.2	41.1	5.3	5.5	30.4	7.5	0.3	0.6	12.3	...	..	2.5	...
Soybean oil meal, 43% protein	9.4	43.1	5.6	5.7	30.4	5.8	0.3	0 6	12.7	...	..	1.5	..
Soybean oil meal, 44% protein	9.2	44 2	5 3	5 6	29.9	5.8	0.3	0.7	14.0	...	16.7	2.0	6.1
Soybean oil meal, solvent, ext.	9.4	46.1	1.0	5.9	31.8	5.8	0.3	0.6	13.8	...	17.1	1.4	6.2
Wheat, hard red winter	10.4	15.2	1 8	2.6	68.3	1.7	0.05	0 4	18 0	...	24.1	0.5	6.3
Wheat, northern spring	9.9	15.8	2.2	2.5	67.8	1.8	0.05	0.4	33.0	...	28.8	0.5	6.4
Wheat, soft, Pacific Coast	10 8	9.9	2.0	2.7	72.7	1.9	...	0.3	27.7	...	26.8	0.5	5.2
Wheat bran	10.3	16.4	4.3	9.9	53.0	6.1	0.1	1.3	56 0	...	63.5	1.4	13.6
Wheat flower middlings	10.3	18.1	4 6	4.9	58.5	3.6	0.07	0 6	39.0	...	44.2	0.8	4.5
Wheat standard middlings	9 9	17.6	5.0	6 7	56.6	4.2	0.1	0.8	53.6	...	44.3	0.8	9.3
Whey, dried	6.5	12.2	0.8	0.2	70.4	9.9	0.9	0.8	1.1	...	5.1	13.0	22.4
Yeast, brewers, dried	6.3	46.8	1.2	2.8	35.7	7.2	0.1	1.5	2.4	...	213.6	14.0	49.1

SUPPLEMENT TO TABLE
Conversion Table for Calculating Feed Formulas

1 pound = 454 grams
1 ounce = 28 4 grams.
1 gram = 1000 milligrams.
1 milligram = 1000 micrograms.
1 microgram per gram is the same as parts per million
To convert milligrams per gram to milligrams per pound multiply by 454.
To convert micrograms per gram or per pound to milligrams per gram or per pound divide by 1000.
To convert milligrams per pound to micrograms per gram or parts per million divide by .454 or multiply by 2.2.
1 I.U. (U.S.P.) unit of vitamin A equals the activity of 0 6 micrograms of B-carotene.
1 microgram of B carotene equals 1 666 I.U. (U S.P.) of vitamin A.

Table A–2

INCUBATION PERIOD FOR DIFFERENT CLASSES OF POULTRY *

Class	Days
Chicken	21
Duck	28
Duck (Muscovy)	35–37
Goose	28–32
Turkey	28
Guinea	26–28
Pheasant	21–24
Peafowl	28
Ostrich	42
Pigeon	18–20
Swan	42

Table A–3

DIGESTIBILITY AND ENERGY VALUE OF POULTRY FEEDS

Feeds	Total Protein Per cent	Digestible Protein Per cent	Total Digestible Nutrients Per cent	Productive Energy Cal./lb.	Metabolizable Energy Cal./lb.
Alfalfa meal.	17	11.1	19.9	217	298
Alfalfa meal.	20	17	36.0	385	588
Animal fat	0	0	207.0	2878	3960
Barley	11	8.1	66.9	813	1256
Blood meal.	80	72	73.6	1014	1417
Bone meal, steamed	13	11.7	24.9	305	421
Buttermilk, dried.	32.5	26.3	72.2	786	1314
Corn, whole or cracked	9	6.8	79.6	1079	1514
Corn, ground	9	7.1	81.3	1105	1547
Corn, gluten meal	41	33.2	60.5	821	1177
Cottonseed meal (4% fat).	43	31.8	64.4	800	1160
Distillers solubles (corn, dried)	25	20	75.2	1020	1440
Fish meal (6.8% fat)	60	54	69.2	941	1324
Kafir	11	9	79.9	1082	1523
Linseed meal (4.5% fat)	34	21.1	38.5	507	696
Meat and bone scrap * (8.5% fat)	50	45	65	874	1239
Milo	10.5	8.9	81.4	1099	1552
Oats	11	8	61	810	1133
Peanut meal (7.5% fat)	43	32.3	60.1	856	1016
Rice, rough	8	5.9	64.6	786	1213
Rye	11.5	7.7	70.1	856	1324
Skimmilk, dried	34	27.5	72.2	599	1302
Soybean meal (0.6% fat)	50	40	64.5	790	1149
Soybean meal (1.2% fat)	44	35.2	62.2	761	1104
Soybean meal (5% fat)	41	33.2	68.3	833	1215
Sunflower seed	16	10.6	66.7	865	1160
Tankage (8% fat)	60	51	67.2	814	1284

* Titus. Scientific feeding of chickens. The Interstate Press, Danville, Ill.

DIGESTIBILITY AND ENERGY VALUE OF POULTRY FEEDS (cont'd.)

Feeds	Total Protein Per Cent	Digestible Protein Per Cent	Total Digestible Nutrients Per Cent	Productive Energy Cal./lb.	Metabolizable Energy Cal./lb.
Vegetable oil	0	0	207	2878	3894
Wheat	12	9.5	73.4	897	1386
Wheat bran	15.6	9.5	41.1	494	766
Wheat middlings, standard	16	11.5	56	694	1051
Whey, dried	12.5	10.1	72.4	616	1249
Yeast, brewers' dried	45	33.8	63.1	572	1207

Table A-4

CHEMICAL COMPOSITION OF POULTRY PRODUCTS (PER CENT)

Product	Moisture	Ash (Minerals)	Crude Protein	Carbohydrates		Fat (Ether extract)
				Crude Fiber	Nitrogen Free Extract	
New-laid egg, entire	65.9	10.0	12.8	..	..	10.6
Chick at hatching time	78.8	1.9	15.3		..	4.1
Broiler, entire bird	65.8	3.9	23.2	..	..	5.6
Leghorn hen, entire fowl	55.8	10.0	12.8		..	10.6
Feather meal	5.8	18.5	87.0	3.9	3.9	13.1
Poultry by-products meal	6.1	17.0	54.6	0.8	6.6	14.9
Poultry blood meal	6.7	8.8	65.3	0.8	..	11.4

Table A–5

GENERAL CHEMICAL COMPOSITION OF THE EGGS OF THE PRINCIPAL SPECIES OF POULTRY *

Constituent	Land Fowl							Water Fowl					
	Chicken				Turkey			Duck			Goose		
	Contents	Albumen	Yolk	Shell	Contents	Alb.	Yolk	Con	Alb.	Yolk	Contents	Albumen	Yolk
Weight Grams	51.6	32.9	18.7	6.1	71.6	44.2	27.4	66.6	40.4	26.2	177.0	110.2	66.8
Water Per cent	73.6	87.9	48.7	0.1	73.7	86.5	48.3	69.7	86.8	44.8	70.6	86.7	43.3
Solids Per cent	26.4	12.1	51.3	6.0	26.3	13.5	51.7	30.3	13.2	55.2	29.4	13.3	56.7
Organic matter Per cent	25.6	11.5	50.2	0.2	25.5	12.8	50.4	29.3	12.4	54.0	28.2	12.5	55.1
Proteins Per cent	12.8	10.6	16.6	0.2	13.1	11.5	16.3	13.7	11.3	17.7	14.0	11.3	18.0
Fats (lipids) Per cent	11.8	0.03	32.6	Trace	11.7	0.03	33.2	14.4	0.08	35.2	13.0	0.04	36.0
Carbohydrates Per cent	1.0	0.9	1.0		0.7	1.3	0.9	1.2	1.0	1.1	1.2	1.2	1.1
Inorganic matter Per cent	0.8	0.6	1.1	5.8	0.8	0.7	1.3	1.0	0.8	1.2	1.2	0.8	1.6

* Reference A. L. Romanoff and A. J. Romanoff. The Avian Egg. John Wiley and Sons, New York.

Table A–6

EGG EQUIVALENTS

Size of eggs—Use in recipes	Peewee	Pullet	Medium	Large	Extra Large	Jumbo
No. of whole eggs per cup... ..	7	6	5	4	4	3
No. of egg whites per cup.......	10	9	8	7	6	6
No. of egg yolks per cup	21	19	17	14	12	10
Ounces per egg without shell .	1.2	1.4	1.7	2.0	2.1	2.5

Shell, frozen and dried egg equivalents

One pound of:	is equivalent to:
Frozen or liquid whole egg	10.2 shell eggs
Dried whole egg	3.6 lbs. liquid whole egg or 36 (3 dozen) shell eggs
Dried yolk	2.25 lbs. liquid yolk
Dried albumen	7.3 lbs. liquid albumen
Liquid whole egg	.55 lbs. liquid white and .45 lbs. liquid yolk
Dried whole egg	.25 lbs. dried white and .75 lbs. dried yolk

Dried and shell egg equivalents

Dried whole egg *Weight*	*Volume*	Equivalent to shell eggs
2 ozs.	2.–2.5 tablespoons	1 egg
6 ozs.	1 pint	12 eggs
1.5 lbs.	2 quarts	50 eggs

Table A–7

PERCENTAGE OF SHRINKAGE OF POULTRY FROM DRESSING AND EVISCERATING, BY KIND AND CLASS OF POULTRY

Kind and Class of Poultry	Live Weight	Approximate Shrinkage from [1]	
		Live to Dressed Weight	Live to Ready-To-Cook Weight [2]
Chickens:	*Pounds*	*Per Cent*	*Per Cent*
Broilers and fryers	Under 4	10 to 12	30 to 35.
Roasters	4 and over	9½ to 11..	28 to 35.
Hens (stewing chickens)	All weights	10 to 11	31 to 36.
Turkeys			
Fryer-roasters	Under 10	10 to 12	28 to 31.
Hens and toms	10 to under 20	9 to 10	21 to 28.
Hens and toms	Over 20	9 to 9½	20 to 23.
Ducks (all classes)	All weights	10 to 12	28 to 33.
Geese (all classes)	All weights	10 to 13	25 to 30.
Guineas (all classes)	All weights	10 to 12	28 to 35.

[1] The figures in this table represent ranges in shrinkage percentages obtained from a number of commercial processors and some farm and laboratory processing operations.
[2] Include giblets (heart, gizzard, and liver) and neck
U.S.D.A. Farmers' Bul 2030

Table A–8

AVERAGE WEIGHTS OF PARTS OF CARCASS OF WHITE PLYMOUTH ROCK COCKERELS AND PULLETS KILLED AT DIFFERENT WEIGHTS, EXPRESSED IN PERCENTAGE OF THE EMPTY WEIGHT [7]

	Males	Females	Males	Females	Males	Females
Approximate slaughter weight	2	2	4	4	6	5
Age in days	103	73	169	189	250	219
Percentage "fill"	2.6	4.8	3.4	2.6	2.9	3.7
Empty weight in grams	967	915	1725	1787	2509	2245
Offal						
Feathers	4.8%	7.2%	7.8%	8.5%	8.1%	7.5%
Blood	4.8	3.7	4.2	3.3	4.2	3.5
Head	3.4	3.1	3.1	2.7	2.8	2.4
Shanks and feet	5.8	5.0	5.5	3.7	4.5	3.6
Total offal	18.7	19.0	20.6	18.2	19.7	16.9
Viscera						
Heart	.48	.49	.42	.48	.45	.45
Liver	2.3	2.5	2.1	1.7	2.0	1.9
Kidneys	.64	.68	.5	.55	.52	.62
Pancreas	.3	.31	.21	.24	.18	.22
Spleen	.2	.26	.17	.18	.16	.21
Lungs	.43	.46	.53	.45	.45	.40
Testicles	.03		.09		.26	
Digestive tract	11.9	11.4	8.6	9.4	7.9	8.6
Total viscera	16.2	16.1	12.6	12.9	12.0	12.4
Dressed carcass						
Skin	7.3	8.0	7.4	9.2	7.6	10 0
Neck	3.9	3.8	3.7	2.9	3.4	2.7
Legs above hock	20.2	18.3	22.1	19.3	22.2	19.0
Wings	6.4	6 2	6.6	5.4	5.9	5.4
Torso	22 0	24.0	24.6	29 3	26.4	30.2
Total dressed carcass	59.9	60 3	64.3	66.1	65 6	67.3
Total bone in dressed carcass	19.1	17.6	19.1	15.0	16.7	14.7
Total flesh and fat in dressed carcass	33.4	34.0	36.0	41.0	40.2	41.8
Total flesh, fat, and edible viscera	40 7	41.9	42.0	47 0	45.9	47.6

[7] Ill. Agr. Expt. Sta. Bul. 278, 1926, and *Egg and Poultry Magazine*, 46 303 1940.

Table A–9

THE PERCENTAGE OF PARTS, COOKING LOSS AND EDIBLE MEAT OF CARCASSES AND PARTS OF DIFFERENT SPECIES AND CLASSES OF POULTRY *

Observation	Chickens			Turkeys		Waterfowl	
	Broilers	Rock Hens	Leghorn Hens	Large	Small	Ducks	Geese
(Av. of 10 birds)							
Ready-to-cook wt. (lbs.)	3.1	4.9	2.8	22.6	6.7	4.9	7.4
Fat rendered out in cooking (%)	1.0	10.2	5.9	5.6	1.6	21.4	6.2
Cooking loss including fat (%)	24.5	32.7	33.7	32.3	24.0	44.5	35.4
Cooked edible meat exclusive of fat (%)	51.0	46.1	46.2	56.7	54.0	38.4	41.4
Legs and Thighs							
Weight (lbs.)	1.0	1.4	0.8	5.2	1.6	1.1	1.6
% of Carcass	32.0	28.4	27.7	23.0	23.9	22.4	21.6
Cooking loss (%)	24.5	37.0	38.0	33.7	26.0	45.1	34.0
Edible meat (%)	53.0	49.2	48.6	53.5	57.0	43.9	47.4
Breast							
Weight (lbs.)	0.8	1.1	0.7	8.3	1.6	1.5	1.8
% of Carcass	26.0	23.2	24.5	36.7	23.9	30.6	24.3
Cooking loss (%)	23.8	34 4	37.9	27.2	27.0	48.5	39.3
Edible meat (%)	63.2	59.1	55.7	67.7	65.0	43.3	47.7
Wings							
Weight (lbs.)	0.4	0.5	0.3	2.1	0.9	0.5	1.2
% of Carcass	13.0	9.4	10.3	9.3	13.4	10.2	16.2
Cooking loss (%)	17.4	27.6	25.8	30 8	15.0	25.4	26.0
Edible meat (%)	49.7	48.9	47.8	48.7	47.0	38.2	35.7
Back and Ribs							
Weight (lbs.)	0.5	1.1	0.6	4.1	1.3	1.1	1.6
% of Carcass	16 0	22.1	21.7	18.1	1.9	22.4	21.6
Cooking loss (%)	25.0	41.1	38.8	37.3	25.0	47.3	38.3
Edible meat (%)	41.2	43.6	43.7	45.0	41.0	26.9	32.8
Neck							
Weight (lbs.)	0.1	0.1	0.1	0.6	0.2	0.2	0.5
% of Carcass	3 0	3 0	3.2	2.7	3.0	4.1	6.8
Cooking loss (%)	26.7	27.8	23.7	34.8	...	...	...
Edible meat (%)		49.7	48.8	43.2	...	...	...
Giblets							
Weight (lbs.)	0.2	0.2	0.1	0.9	0.5	0.3	0.9
% of Carcass	6.0	4.4	5.1	4 0	7.0	6.1	12.2

* Winter and clements. J. Am. Dietetic Assoc. 33 800 1957.

Table A–10

COMPARATIVE COSTS OF EDIBLE PORTION OF CHICKEN, EGGS, TURKEY AND SOME CUTS OF BEEF & PORK

Kind of Meat		Average Weight Raw			Average Cooked		Cleveland 4-18-58	
		Ready to Cook (Bone in)	Bone	Edible Portion Only	Edible Portion After Cooking	Edible Portion Compared Ready to Cook	Retail Price Ready to Cook Samples	Cost of Cooked Edible Portion
Beef—Chuck Roast (d)		Lbs.	Lbs.	Lbs.	Lbs.	Per cent	Per Lb.	Per Lb.
8 samples		4.16	1.70	2.46	1.63	39.2	$ .59	$1.51
Round Roast 2 samples		3.8	.0	3.8	2.13	56.0	.86	1.54
Pork—Rib & Loin (d)							$ .69	$1.83
Chops 2 samples		1.97	0.89	1.08	0.74	37.6	.99	2.63
Chickens *	Aver. Live Wt.						$ .40	$0.80
60 Broilers (b)	3.43	2.57	0.82	1.75	1.29	50.2	.60	1.19
Cut-up (b)							.60	1.12
Legs & Thighs		0.81	0.19	0.62	0.43	53.3	.80	1.50
							.60	0.94
Breasts		0.64	0.10	0.54	0.41	63.4	.90	1.42
20 Hens (a)	5.2	3.56	0.9	2.66	1.86	52.2	.49	0.94
20 Roasters (a)	6.8	5.07	1.18	3.72	2.60	51.3	.59	1.15
Turkeys *								
6–12 weeks (c)	7.67	5.59	1.23	4.27	2.57	46.0	$ .59	$1.28
6–18–20 wks. (c)	14.40	10.56	1.98	8.60	4.88	46.2	.49	1.07
4–26 wks. (c)	20.43	15.75	3.89	11.86	9.25	58.7	.49	0.83
Eggs (e)							$ .48	$0.54
8 = 1 lb.		1.0	0.11	0.89	0.89	0.89	.64	0.72

J. I. Taggart, Hatch Master Incubator Co., Cleveland, O. 1958.

(a) Brown, P. B. and Bean, H. W. (University of Illinois) "The Yield of Edible Meat from Different Market Classes of Chickens." Poultry Science, March, 1952. (b) Tadle, Julieta, Lewis, Martha Nelson, Winter, A. R. Ph. D. and Jaap, R. G. (Ohio State University) "Cooked, Edible Meat in Parts of Chicken." Journal of The American Dietetic Assn., June, 1955. (c) Scott, M. L. Ph. D. (Cornell University) "Composition of Turkey Meat." Journal of The American Dietetic Assn., October, 1956. (d) Alexander, Lucy M. and Schopmeyer, Grace E. U. S. D. A. "Yield of Edible Portion of Chicken and Various Meats Cooked by Different Home Methods." Food Technology 1949. * Edible Portion includes Skin Adhering Fat & Giblets. (e) Poultry and Egg National Board.

Table A-11

COMPARISON OF NUTRIENT COMPOSITION OF COOKED MEATS & EGGS *

Meat	Protein	Fat	Moisture	Food Energy	Riboflavin (B_2)
	Per cent	Per cent	Per cent	Calories per lb.	Per cent of daily needs for an av. adult found in 1 lb.
Turkey (Roasted)					
White Meat	34.3	7.5	58	923	15
Dark Meat	30.5	11.6	57	1022	33
Chicken (Roasted)					
White Meat	31.5	1.3	68	621	11
Dark Meat	25.4	7.3	67	754	22
Beef (Cooked)					
Round Steak	27.0	13.0	59	1049	8
Porterhouse Steak	23 0	27 0	49	1539	7
Rump Roast	21.0	32.0	46	1701	6
Hamburger	22 0	30 0	47	1648	7
Pork (Cooked)					
Ham	24.0	33 0	42	1800	9
Loin Chops	23.0	26.0	50	1499	9
Lamb (Cooked)					
Rib Chops	24 0	35.0	40	1871	10
Shoulder Roast	21.0	28.0	50	1539	8
Eggs (Boiled)					
8 = 1 lb.	13.4	10.5	74	648	56

* J. I Taggart. Hatch Master Incubator Co , Cleveland, O 1958

Index